SEVENTEENTH ANNUAL

REPORT

OF

Rutgers Scientific School,

THE STATE COLLEGE

FOR THE

Benefit of Agriculture and Mechanic Arts,

NEW BRUNSWICK, N. J.

FOR THE YEAR 1881.

ORANGE, N. J.:
SAMUEL TOOMBS, PRINTER,
1881.

SEVENTEENTH ANNUAL

REPORT

OF

Rutgers Scientific School,

THE STATE COLLEGE

FOR THE BENEFIT OF

AGRICULTURE AND THE MECHANIC ARTS,

NEW BRUNSWICK, N. J.,

FOR THE YEAR 1881.

ORANGE, N. J.
SAMUEL TOOMBS, PRINTER,
1881.

Board of Visitors.

FIRST CONGRESSIONAL DISTRICT.

	Residence.	Term Expires.
Hon. THOMAS H. DUDLEY,	Camden,	April 12, 1882.
J. M. SMALLEY, Esq.,	Roadstown,	April 12, 1882.

SECOND CONGRESSIONAL DISTRICT.

Hon. WILLIAM PARRY,	Cinnaminson,	April 12, 1883.
WILLIAM S. TAYLOR, Esq.,	Burlington,	April 12, 1882.

THIRD CONGRESSIONAL DISTRICT.

COLLIN MEIRS, Esq.,	Cream Ridge,	April 12, 1882.
JAMES NEILSON, Esq.,	N'wBrunswick,	April 12, 1882.

FOURTH CONGRESSIONAL DISTRICT.

JOHN DeMOTT, Esq.,	Middlebush,	April 12, 1883.
CALEB WYCKOFF, Esq.,	Belvidere,	April 12, 1882.

FIFTH CONGRESSIONAL DISTRICT.

Rev. JOHN F. ROBINSON,	Paterson,	April 12, 1882.
		April 12, 1882.

SIXTH CONGRESSIONAL DISTRICT.

PATRICK T. QUINN, Esq.,	Newark,	April 12, 1882.
WILLIAM M. FORCE, Esq.,	Newark,	April 12, 1883.

SEVENTH CONGRESSIONAL DISTRICT.

ABRAHAM W. DURYEE, Esq.,	New Durham,	April 12, 1882.
JAMES STEVENS, Esq.,	Jersey City,	April 12, 1882.

OFFICERS.

Hon. WILLIAM PARRY, - - Chairman.
GEORGE H. COOK, - - - Secretary.

REPORT OF STATE BOARD OF VISITORS.

To His Excellency, George C. Ludlow, Governor of the State of New Jersey:

HONORED SIR—The Board of Visitors of the State Agricultural College herewith present their seventeenth annual report of the present condition and course of instruction, as required in the Act creating the Board, entitled "An Act appropriating scrip for lands granted to the State of New Jersey by the Act of Congress, approved July 2, 1862," and approved April 4, 1864.

The Board has held two regular meetings since the last report was made, have attended the examinations of the students, have visited the laboratories and collections of the college, and have visited the farm belonging to the Agricultural College, to witness the business and experiments in progress there. And upon each of these points they would respectfully report:

The first meeting of the Board was held on the 20th of December, 1880.

Present: Hon. William Parry, President; and Messrs DeMott, Dudley, Duryee, Force, Quinn and Taylor.

The members attended the following examinations:

Seniors, in Organic Chemistry, by Prof. Austen.

Seniors, in Analytical Chemistry, by Prof. Austen.

Juniors, in Analytical Geometry, by Prof. Bowser.

Juniors, in German, by Prof. Meyer.

Juniors, in Political Economy, by Prof. Atherton.

Sophomores, in Intellectual Philosophy, by Prof. Doolittle.

Freshmen, in History, by Prof. Hart.

Linear Drawings of all the classes, by Prof. Hasbrouck.

An exercise in Military Drill, by Lieut. Holmes.

At the conclusion of the examination the members met for consultation and the consideration of the merits of the course of instruction, and the proficiency of the students in

the various branches. Much satisfaction was expressed at the result of examinations in Political Economy, History and the exercise in Military Drill. The following resolution was unanimously approved, viz.:

Resolved, That we, the State Board of Visitors to the Agricultural College, having attended the examinations of the several classes, hereby express our judgment that the students are making satisfactory progress in their studies, that they are well taught, that the branches of learning taught are those "relating to Agriculture and the Mechanic Arts" in the true spirit of the law of Congress which endowed the institution, and that the Trustees of Rutgers College are faithfully and liberally fulfilling their contract with the State of New Jersey.

President Campbell stated that the corps of instructors had been strengthened by the addition of Lieutenant S. N. Holmes, of the United States Army, who takes charge of the drill of the students and of the Mathematics of the Freshman Class; and of Prof. Charles E. Hart, who divides with Prof. Doolittle the teaching of English Literature.

President Campbell and the Secretary called the attention of the Board to the recent action of the United States Senate in passing a bill to create an educational fund, which they thought would be useful to New Jersey, and especially to this college. The matter was discussed, the action of the Senate fully approved, and it was resolved that the members of the Board should use their influence to enlist our Representatives in Congress in passing the bill in the House. The Board then adjourned.

The second meeting was held at the college for the semi-annual examination of the students, June 16, 1881. There were present, Hon. William Parry, President, and Messrs Dudley, Duryee, Neilson, Smalley, Taylor and Wyckoff.

The Secretary reported that the bill to create an educational fund, which had passed the United States Senate, failed to be acted on by the House. In view of the bill being brought up again in Congress, it was

Resolved, That the Board heartily approves of the provisions of said bill and appoints Mr. Dudley to attend to its renewal, and to such preparations as may facilitate its passage.

William Janeway, a member of this Board, having died since its last meeting, the following preamble and resolutions were adopted:

WHEREAS, William R. Janeway, Esq., of Franklin township, Somerset county, departed this life on the ninth day of April; and

WHEREAS, Mr. Janeway has been a member of this Board

since April, 1873, was a punctual attendant at all our meetings, and always evinced an active and hearty interest in the prosperity of the institution, and in remembrance of his virtues and usefulness, it is

Resolved, That this Board has learned with sorrow of the death of their respected associate, William R. Janeway, Esq. That we remember his strict integrity, his active interest in every good work, his earnest efforts to sustain and increase the usefulness of this institution, and his pleasant and genial intercourse with us.

Resolved, That we sympathize with his family in their affliction, and that these resolutions be entered on our minutes, and a copy of them be sent to his family.

Examinations were then attended as follows:

Juniors, in Calculus, by Prof. Bowser.

Juniors, in Astronomy, by Prof. Merriman.

Juniors, in Analytical Chemistry, by Prof. Austen.

Juniors, in German, by Prof. Meyer.

Sophomores, in Descriptive Geometry, by Prof. Hasbrouck.

Sophomores, in Railroad Curves, by Prof. Bowser.

Sophomores, in Constitutional History of England, by Prof. Atherton.

Sophomores, in Mental Philosophy, by Prof. Doolittle.

Freshmen, in French, by Prof. Meyer.

Freshmen, in Botany, by Prof. Van Dyck.

Freshmen, in English Literature, by Prof. Hart.

Freshmen, in Plane Trigonometry, by Lieut. Holmes.

There was an exhibition of the Draughting of the different classes under the direction of Prof. Hasbrouck, and Laboratory Practice under the supervision of Prof. Austen.

The board listened to the reading of the following theses by members of the graduating class:

John Bruere, New Egypt, N. J.: "Examination of Samples of Cream of Tartar sold in New Brunswick."

Thomas H. Grant, Red Bank, N. J.: "Asphaltic Pavement."

Frederick W. Malcolm, New York City: "Railroads, English and American."

Oakley A. Johnson, Hackettstown, N. J.: "The Hudson River Tunnel."

John F. McWilliam, East Millstone, N. J.: "Analyses of Quack Remedies."

Robert C. Plume, Jersey City, N. J.: "Railroad Switches."

Charles S. Rusling, Lawrenceville, Pa.: "Analyses of Baking Powders."

John T. Marshall, Metuchen, N. J.: (Thesis not read).

After due deliberation, the Board directed the Secretary to

record in the minutes the satisfaction of the Board with the course of instruction given by the professors, with the progress of the students, and with the manner in which the trustees of Rutgers College are fulfilling their responsibilities to the State; and it was

Resolved, That the members of the Board deem it their duty to visit the school in its daily working, and they are hereby requested and authorized, individually and as their judgment dictates, to attend the recitations and exercises of the students.

President Campbell reported that the year just closing had been one of remarkable freedom from disorders and infractions of college regulations; that the scientific students, in particular, were showing great earnestness of purpose, and their practical and experimental studies gave them full occupation and exercise.

The working laboratory for students has been much enlarged in its fixtures and apparatus during the year. The appliances, the filter press and the atmospheric pump, by which the tedious processes of filtering have been shortened, are very satisfactory. The addition of a new Bunge Balance gives an increased facility for accurate and quick weighing. A room is now set apart for the use of students engaged in original research, and two students have been using it. The abundant supply of gas for heating purposes, and the water-supply, with high pressure, gives great and desirable facilities for convenient and accurate work. The apparatus supply-rooms show an increase in the amount of stock carried. The book-keeping and system of recording students' work is most satisfactory.

The Museum of Natural History is an important adjunct to the teachers' labor. It is a school for object-teaching, and those who visit it imbibe a vast amount of knowledge without effort and in the most interesting manner. The collections are increasing in variety and richness; those in Geology and Mineralogy are particularly good. There is a fine collection of the woods of the State and one, of smaller-sized specimens, of all the varieties of wood in the United States. The collection of shells is large and well selected, and growth is noticeable in every department.

The old system of agriculture made a farm an almost self-supporting establishment. The bread, the butter, the cheese, the meat, the cloth, the leather and most of the simple implements of husbandry were made on the farm, and by the farmer and his family. As long as this system continued, agriculture was almost stationary. It was adapted to a new country and to a primitive state of society; no one could ever learn to do so many things well, or even to judge

whether all of them were well done. It was only when the division of labor came to be appreciated and put in practice that the arts of industry began to improve. Those arts which first adopted this division of labor are the ones which have made the greatest improvements and done the most to give efficiency and productiveness to human industry.

Agriculture, from its covering so wide a field of labor, has been the slowest to apply this simple principle and to get the benefits of it in its practice. The removal from the farm of the mill and the bakery, of the creamery and the cheese factory, of the spinning-wheel, the loom and the tailor-shop, the tannery and the shoe-shop, the shops of the carpenter, the blacksmith, the butcher, and the subsidiary but necessary branches of work, has enabled workmen to concentrate their undivided attention and skill upon single branches of industry, and has within the last fifty years done more to advance agriculture than all the centuries before it.

The division of labor has enabled thoughtful workmen to study the principles on which the practice of different arts depends, and have brought men to know that the best results of labor can only be attained when they study the reason *why*, as well as the art *how*, work is rightly done.

Chemistry, natural history and physics are furnishing the principles which educated and trained men are to use in carrying on and improving their arts. Whether these are to be studied before or after the processes of the arts are in operation must depend on the character of the arts themselves. For the surveyor, the engineer, the architect, the manufacturers of iron, copper and other metals, of sugar, salt, soda, etc., of colors, medicines and drugs, they must come first; but in the case of agriculture, experience indicates that practice precedes theory, and that a farmer must know the usual way of doing his work before he is prepared to study its principles and apply them to the improvement of his practice.

In the present state of the arts, and when it is everywhere admitted that improvements in them must come from the application of scientific principles, there can be no question that institutions for the study and investigation of science are necessary. The institution of which we are visitors is an attempt to meet this necessity; and to the full extent of its means, it is doing its work well. The students who have acquired their education in it are finding remunerative employment, which they could not have entered upon without the preparation they have received here, and there are places continually opening which there are no competent men to fill. This is more especially true of positions of engineers, chemists, draughtsmen, machinists, etc., in which

specialties are pursued, than it is in agriculture, where a longer course of practice is necessary before a young man can safely direct operations.

The establishment of the New Jersey Agricultural Experiment Station, mainly under the direction of this Board, meets the wants of farmers for more of the principles which underlie their art. It has only just begun its work, but it is receiving the hearty co-operation and support of the farmers of the State, and is sending out to them bulletins containing the results of analyses and investigations on fertilizers, cattle-foods, fodders, milk, etc., thus stimulating them to study their own calling and to find profit in it. The farm of the Agricultural College affords the opportunity for making proper experiments, and the rooms of the Scientific School and of Rutgers College furnish the places for the necessary chemical laboratories and experiments.

Very interesting and instructive experiments have been carried on in the growing of Indian corn and wheat with different fertilizers, comparing the milk product of different breeds of cows, noting the effect of different fodders on the health and milk product of cattle, analyzing various chemical articles which may be used for feeding and commercial fertilizers, testing the action of green sand-marl on growing plants, studying the sweet-potato disease, etc. These are made public in the bulletins issued from the Station at intervals of a few weeks, and are printed in annual reports of the Station to the Legislature. Nearly two thousand copies of these bulletins are sent to farmers as soon as they are issued.

We are gratified in being able to report the workings of this institution, and what it is so well doing to give efficiency and dignity to labor and to advance the material interests of "agriculture and the mechanic arts."

The Board would further report that the Trustees of Rutgers College are faithfully and liberally fulfilling their contract with the State. The teachers of the Scientific School receive every cent of the money arising from the United States donation to the State. The buildings, apparatus and farm are all the property of Rutgers College, and paid for by the trustees, and are used for the school without any charge on the State fund.

All of which is respectfully submitted.

WILLIAM PARRY,

President.

TRUSTEES' REPORT.

RUTGERS COLLEGE,
NEW BRUNSWICK, December 1, 1881.

To His Excellency George C. Ludlow, Governor of the State of New Jersey:

SIR—In compliance with the act of Congress, approved July 2, 1862, and the act of the Legislature of New Jersey, approved April 4, 1864, I beg leave to submit, on behalf of the Trustees of Rutgers College, the seventeenth annual report of Rutgers Scientific School.

I. THE FACULTY.

The faculty of the institution is now constituted as follows:

Rev. William H. Campbell, D. D., LL. D., President, and Professor of Moral Philosophy.

George H. Cook, Ph. D., LL. D., Vice-President, and Professor of Geology and Agriculture.

Rev. Theodore S. Doolittle, D. D., Professor of Rhetoric, Logic and Mental Philosophy.

John C. Smock, A. M., Professor of Mining and Metallurgy.

George W. Atherton, A. M., Professor of History, Political Economy and Constitutional Law.

Rev. Carl Meyer, D. D., Professor of French and German.

Francis C. Van Dyck, A. M., Professor of Inorganic Chemistry and Physics.

Edward A. Bowser, M. S., C. E., Professor of Mathematics and Engineering.

Isaac E. Hasbrouck, A. M., Professor of Mathematics and Graphics.

George B. Merriman, A. M., Professor of Mathematics, Astronomy, and Experimental Mechanics.

Peter Townsend Austen, Ph. D., F. C. S., Professor of Analytical and Applied Chemistry.

Francis A. Wilber, B. S., Assistant in Analytical Chemistry.

Samuel N. Holmes, First Lieutenant Thirteenth United States Infantry, Professor of Military Science and Tactics.

II. COURSES OF STUDIES AND DEGREES.

The courses of study in the Scientific School are as follows:

1. *A course of four years in Civil Engineering and Mechanics.*

2. *A course of four years in Chemistry and Agriculture.*

3. *A special course of two years in Chemistry.*

4. *A special course of two years in Agriculture.*

5. *Post-Graduate courses.*

The SPECIAL COURSE in Chemistry is intended for the convenience of students who wish to devote themselves exclusively to that branch of study. Greatly-increased facilities have recently been provided for them in the Laboratory and Lecture-rooms, allowing the full employment of their time. On completing the course, they receive a special certificate.

Provision is also made for PARTIAL STUDENTS, who may enter at any time, and elect, under the advice and direction of the Faculty, such studies as they may be found qualified to pursue with classes already formed. Such students are subject to the general regulations and discipline of the institution They are required to have their time fully occupied, and to pass such examinations as may be prescribed in each case. On leaving, they receive certificates stating the studies pursued and the amount of work performed in each.

The two principal courses cover a period of four years each. The studies for the first year are the same in both courses, and are arranged with special reference to the wants of young men who desire to fit themselves to become land-surveyors, or to enter any department of skilled industry, but are unable to remain four years in the institution.

At the end of the first year, students elect whether to pursue the course in Civil Engineering and Mechanics, or that in Chemistry and Agriculture, and for the remaining

three years their studies are directed with particular reference to the choice made. Some studies, however, of a general nature, such as History, English Literature, Political Economy, Moral Philosophy and others, are interspersed throughout the entire four years, in order that students may not only acquire a thorough preparation for their special pursuits in life, but may at the same time receive a liberal training which will fit them to discharge wisely and usefully the duties of good citizenship.

Students completing either of the four years' courses receive the degree of Bachelor of Science.

Heretofore, the degree of Master of Science has been conferred, in course, upon all graduates of three years' standing. The Trustees have long been convincd that the practice of conferring high academical honors, indiscriminately, without regard to the character or attainments of those who receive them, is an unfair discrimination against those who have honorably earned recognition, and calculated to bring all such marks of distinction into undeserved discredit. They have accordingly decided to confer hereafter no degrees "in course," and they regard this as an important step in the direction of maintaining a high standard of scholarship.

The degrees of Civil Engineer and Doctor of Philosophy are conferred for distinguished professional or practical success, or on examination in prescribed subjects.

A schedule of the several courses of study accompanies this report.

III. POST-GRADUATE STUDIES.

In addition to these courses of study for the under-graduates, several post-graduate courses have been arranged (and the number will be increased as occasion requires), for students who desire, after graduation, to pursue special lines of training and research.

In Chemistry, students can pursue special studies and investigations in the Analytical Laboratory, under the direction of a professor, upon subjects connected with industrial or professional life.

In Geology and Natural History, the large collections in Geological Hall are available for extended courses of study, and can be used, under the direction of a professor, for special study in Geology, Mining, Metallurgy, and the various branches of Engineering.

In Agriculture, the well-equipped farm and laboratories give unusual opportunities for advanced studies in this department, and every facility is afforded for their use.

In Mathematics, instruction will be given in any of the following subjects: Geodesy, with practice; Higher Mathematics (pure); Theoretical and Practical Astronomy; the use of Physical Apparatus.

In Modern Languages, the course will include Lectures on French Literature, Lectures on German Literature, Lectures on German Etymology, on German Mythology, and on the Phonology and Morphology of the Indo-Germanic Languages, as bearing on German; and an advanced course in the History and Literature of the English Language.

In the Department of Political and Social Science, provision is made for instruction in an advanced course in Political Economy; in the Constitutional History and Jurisprudence of the United States; in the History of the English Constitution; and in the elements of Roman Law.

These various subjects, according to the choice of students, will be arranged in courses of one, two or three years.

Students completing a full course of two years, in any two of the departments, will be entitled to the degree of Doctor of Philosophy.

IV. TERMS OF ADMISSION.

The conditions of admission to the regular courses of study and to the Special Course in Chemistry have recently been somewhat increased, and are now as follows:

Applicants must be sixteen years of age, and of good moral character; and, if they come from other institutions, must bring a certificate of honorable dismission. They are required to pass a satisfactory examination in English Grammar and Spelling, Descriptive Geography, Physical Geography, History of the United States, Arithmetic, including the Metric System, Algebra to Series, and the whole of Plane Geometry.

The regular examinations for admission to the Freshman Class are held on the Friday and Saturday preceding the annual Commencement, and on the day before the opening of the fall term. Candidates for advanced standing are examined in the preparatory studies, and in those already pursued by the class which they propose to enter.

V. STUDENTS.

Of the four classes now in the institution, which will be graduated in June, 1882, 1883, 1884 and 1885, respectively, the Senior Class consists of five students, the Junior Class of three, the Sophomore Class of fourteen, and the Freshman Class of seventeen. There are also seven special students, making a total of forty-six now in attendance.

There have been in the institution during the year, seventy-

four students, of whom one was from Scotland, two from the State of Pennsylvania, ten from the State of New York, one from the State of Illinois, and the remaining fifty from the State of New Jersey, representing thirteen counties, as follows:

Bergen,	2	Monmouth,	7
Cape May,	1	Morris,	1
Essex,	10	Ocean,	1
Gloucester,	2	Passaic,	1
Hudson,	1	Somerset,	5
Hunterdon,	1	Union,	3
Mercer,	2	Warren,	1
Middlesex,	18		

Under the law of New Jersey, designating this institution as "The State College for the Benefit of Agriculture and the Mechanic Arts," forty students from this State are entitled to free tuition for the entire course. These students are admitted on the recommendation of the Superintendent of Schools in each county, and are distributed among the counties in proportion to their representation in the Legislature, as follows:

Atlantic,	1	Middlesex,	2
Bergen,	1	Monmouth,	2
Burlington,	2	Morris,	2
Camden,	2	Ocean,	1
Cape May,	1	Passaic,	3
Cumberland,	1	Salem,	1
Essex,	6	Somerset,	1
Gloucester,	1	Sussex.	1
Hudson,	6	Union,	2
Hunterdon,	1	Warren,	1
Mercer,	2		

In filling these State scholarships the Trustees have, from the first, adopted the most liberal interpretation of the law; and, in fact, have gone far beyond its requirements.

In cases where the scholarship is not filled by the county entitled to it, the Trustees have adopted the policy of allowing it to be filled temporarily, with the consent of the County Superintendent, by an applicant from some other county; and, in general, tuition is habitually remitted to students who are unable to pay that in addition to the other expenses of procuring an education.

The following tables, which have been prepared with great care by Prof. Hasbrouck, present, in a condensed form, a complete exhibit of what has been done in the way of furnishing free tuition, since the institution was organized, together with a summary of attendance, by years and by counties:

I.—Table Showing the Number of Students from each County at the Present Time, and their Relation as to Tuition.

COUNTIES.	Scholarships.	ON SCHOLARSHIP.				Free.	Pay.	Total.
		By Appointment.			Of Other Counties.			
		From County.	From Other Counties	Total.				
Atlantic	1							
Bergen	1	1		1		2		3
Burlington	3	1		1				1
Camden	2		1	1				
Cape May	1	1		1				1
Cumberland	1		1	1				
Essex	6	4		4		2	2	8
Gloucester	1	1		1				1
Hudson	6		4	4				
Hunterdon	1	1		1				1
Mercer	2	1		1				1
Middlesex	2	2		2	2	2	1	7
Monmouth	2	2		2	1			3
Morris	2	1		1				1
Ocean	1	1		1				1
Passaic	2		1	1				
Salem	1							
Somerset	1	1		1	4		1	6
Sussex	1		1	1				
Union	2	2		2	1			3
Warren	1							
Totals, New Jersey	40	19	8	27	8	6	4	37
Other States								9
Grand Total								46

II.—Table Showing the Number of Students from each County, from the Beginning, and their Relation as to Tuition.

COUNTIES.	Scholarships.	ON SCHOLARSHIP.				Free.	Pay.	Counted twice.	Total.
		By Appointment.			Of Other Counties.				
		From County.	From Other Counties.	Total.					
Atlantic	1	1	1	2		1			2
Bergen	1	3	1	4		4			7
Burlington	[illegible]	1	3	4					1
Camden	[illegible]	1	2	3					1
Cape May	1	1	1	2					1
Cumberland	1	1	1	2	1	1			3
Essex	[illegible]	18	4	22		9	3	1	28
Gloucester	1	4		4	1			1	4
Hudson	[illegible]	4	9	14		2	2		8
Hunterdon	[illegible]	8		3					3
Mercer	[illegible]	6		6		4		1	9
Middlesex	[illegible]	15		15	10	30	28	3	70
Monmouth	[illegible]	9		9	3	5	1	1	17
Morris	[illegible]	10		10	2	2	2	1	14
Ocean	1	3		3					3
Passaic	[illegible]	2	1	3		1			3
Salem	1		1	1					
Somerset	1	5		5	6	8	4	2	22
Sussex	1	1	1	2		1			2
Union	[illegible]	9		9	2	7	6	1	23
Warren	1	2		2	1				1
	[illegible]	99	25	124	25	75	46	14	231
Other States									68
Grand Total									299

III.—Table Showing the Relation of Students as to Tuition for each Collegiate Year from the Beginning.

COLLEGIATE YEARS.	NEW JERSEY.				Other States.	Grand Total.
	On Scholarship.	Free.	Pay.	Total.		
1865–66	1	2	2	5	2	7
1866–67	8	7	5	20	3	23
1867–68	13	17	7	37	6	43
1868–69	17	10	4	31	7	38
1869–70	15	13	3	31	5	36
1870–71	20	11	8	39	10	49
1871–72	18	15	7	40	14	54
1872–73	17	9	7	33	11	44
1873–74	14	15	5	34	14	48
1874–75	12	13	9	34	14	48
1875–76	15	13	8	36	9	45
1876–77	17	15	5	37	6	43
1877–78	14	12	6	32	7	39
1878–79	20	5	8	33	5	38
1879–80	24	8	3	35	7	42
1880–81	33	5	3	41	9	50
1881–82	27	6	4	37	9	46

IV.—Table Showing the Number of Students Present by Counties, from the Beginning, for each Collegiate Year.

COUNTIES.	Scholarships.	COLLEGIATE YEARS.																
		1865–66.	1866–67.	1867–68.	1868–69.	1869–70.	1870–71.	1871–72.	1872–73.	1873–74.	1874–75.	1875–76.	1876–77.	1877–78.	1878–79.	1879–80.	1880–81.	1881–82.
Atlantic	1	--	----	----	----	----	----	----	1	1	1	1	----	----	----	----	----	----
Bergen	1	--	----	----	1	----	2	1	----	----	----	1	1	----	----	----	----	3
Burlington	3	--	----	----	----	----	----	----	----	----	----	----	----	----	----	----	1	1
Camden	2	--	----	----	----	----	----	----	1	----	----	----	----	----	----	----	----	----
Cape May	1	--	----	----	----	----	----	----	----	----	----	----	----	----	1	1	1	1
Cumberland	1	--	1	1	----	2	2	2	----	----	----	----	----	----	----	----	----	----
Essex	6	2	2	3	5	6	6	3	2	1	3	4	2	1	----	3	8	8
Gloucester	1	--	----	----	----	----	1	1	1	1	1	----	----	----	----	1	2	1
Hudson	6	--	----	----	----	----	1	4	4	3	2	----	----	1	1	2	1	----
Hunterdon	1	--	----	----	----	----	----	1	1	1	1	1	1	----	1	1	1	1
Mercer	2	--	2	5	2	3	1	1	----	1	1	1	1	----	1	2	2	1
Middlesex	2	--	6	13	9	7	9	7	10	14	17	16	17	16	15	15	9	7
Monmouth	2	--	2	4	4	4	2	1	----	1	1	1	2	4	4	3	6	3
Morris	2	--	1	1	1	3	4	5	3	2	2	1	2	3	4	3	1	1
Ocean	1	--	----	----	----	----	----	1	1	1	----	----	----	----	1	1	1	1
Passaic	2	--	1	1	1	----	----	----	----	1	1	1	1	----	1	1	1	----
Salem	1	--	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Somerset	1	1	3	6	6	4	4	5	3	1	----	----	----	1	2	2	2	6
Sussex	1	1	1	----	----	----	----	----	----	----	----	1	1	1	----	----	----	----
Union	2	1	1	3	2	2	7	8	6	6	6	8	8	4	1	----	4	3
Warren	1	--	----	----	----	----	----	----	----	----	----	----	1	1	1	----	1	----
T'ls New Jersey	40	5	20	37	31	31	39	40	33	34	34	36	37	32	33	35	41	37
Other States	--	2	3	6	7	5	10	14	11	14	14	9	6	7	5	7	9	9
Grand Totals	--	7	23	43	38	36	49	54	44	48	48	45	43	39	38	42	50	46

V.—Table Showing the Occupation of 99 *of the Students of Rutgers Scientific School who have Graduated, and of* 60 *who have left without Graduating, from the beginning to September,* 1881, *inclusive, these being the only ones whose occupation is certainly known.*

STUDENTS.	OCCUPATIONS.							
	Engin'r.	Arch't.	M'f'r.	Farmer.	M. D.	Lawyer.	Teacher.	Business.
Who graduated	41	3	14	6	8	8	9	10
Per cent	41	3	14	6	8	8	9	10
Who did not graduate	6	2	6	13	4	3	4	22
Per cent	10	3	10	22	6	6	6	37
Totals	47	5	20	19	12	11	13	32
Per cent	29	3	13	12	8	7	8	20

VI. SPECIAL DEPARTMENTS.

The method and scope of work in the several departments of the institution have undergone no particular change since the date of the last report, though it is but just to the gentlemen in charge to say that that there are in each department gratifying indications of steady and vigorous growth.

1. MATHEMATICS.

In this course during the first year students are instructed in Algebra, Geometry, Trigonometry and Surveying, and receive sufficient field practice to make them able to survey farms, either with the compass or the transit, and to determine the magnetic variations. Those who take the Engineering course for the full term of four years are instructed in Descriptive Geometry, Railroad Curves, Analytic Geometry, Calculus, Mechanics, Civil Engineering, Bridge-building, Geodesy, etc., having at the same time daily practice in Draughting. Special attention is given to Mathematics rather than to Engineering, for the reason that a thorough training in the former necessarily precedes and is essential to a good knowledge of the latter, and in a four years' course a student cannot get both. It is pretty generally admitted by engineers, both civil and mining, that students should first take a thorough course in Mathematics, and obtain a knowledge of the theory of engineering, and then enter the field, or the office, as engineers' assistants and continue their course. In Geodesy the students receive instruction in making a reconnoissance survey for a protracted triangula-

tion system; the measurement of the base line, with its several reductions; erection of signals, measurement of horizontal angles and their adjustment by the "Method of Least Squares"; computation of latitude, longitude and azimuths, etc. For the past seven years some of the students of this department have been employed on the geodetic survey of New Jersey, and on the State topographical survey, with good results. The aim of the instruction is to ground the students firmly in Mathematics and to give them a knowledge of the theory of Engineering, so that after graduation they may be able to pursue understandingly and continuously an advanced course of mathematical study, or to go into the field or the office as engineers' assistants and do useful work.

2. GRAPHICS.

During the past year, instruction in Descriptive Geometry has been given the Sophomore Class. A text-book was used in the recitation-room as a convenient method of bringing principles to the students' attention, and of discussing them. At the same time, problems prepared by the professor, and furnishing novel and practical applications of these principles, were assigned for solution in the draughting-room. These have proved of very great benefit, not only in giving a meaning to what might otherwise have seemed abstractions, but in familiarizing the mind with the relations and properties of geometrical magnitudes, and with the many artifices of solution which are invaluable to the draughtsman as well as to the descriptive geometer. The work of the year in this respect has been exceptionally satisfactory, the problems solved being more numerous and more difficult than those of previous years, and the solutions furnished possessing unusual merit in originality of method as well as in comprehension of principles. Many of the problems were more difficult than those assigned for the "Science Examinations" in England. The subjects of the Intersection of Surfaces, Shades and Shadows and Linear Perspective were illustrated by problems which stimulated investigation and ingenuity on the part of the student. At the end of the year the growth in the power of synthetic and analytic reasoning was felt by the students themselves, and it was evident to the professor.

Instruction to the other classes was entirely oral, in connection with work at the draughting-table. During the hours devoted to this work, questions and discussions, either among the students themselves or with the professor, are always in order and generally in progress. As a result, not

only are methods learned, but also the reasons for them, with the occasion and effects of modifications. From this comes a more thorough mastery of the principles and a greater facility in their application. In short, the student grows into an intelligent and ready draughtsman. The work with these classes was in the construction of geometrical problems, topographical drawing, lettering, the use of colors and practice in shading, cutting of timbers, finished drawings, etc.

Attention has been called in previous reports to the great hindrance to the most effective work in this department, arising from the fact that very rarely does any new student coming here, except from the Rutgers College Grammar School, have even the most elementary knowledge of right-line drawing. The names of the most common draughting instruments are entirely unknown to him. Of course, he knows nothing of their purposes or of the manner of using them for the simplest operations. Again would we protest to the people of the State against this unnecessary waste of time—in the curriculum and to the student—a waste which is the more to be lamented because occurring when opportunities afforded for advanced instruction, based upon the principles of mathematics and mechanics here taught, cannot be improved by reason of a want of elementary instruction in this subject. The possibilities of at least one year are lost from this cause. And since our students are preparing for various and dissimilar vocations, the arrangement of special courses in drawing, with reference to such vocations, and advanced instruction in these courses, is not to any great extent practicable, and the limited time available becomes, therefore, the more valuable. Besides, a few of the students, as indicated above, having had some instruction in elementary drawing, must either repeat the course or a difficulty arises in providing proper work and oversight for different members of the same class, which cannot be well met without increased teaching force and facilities. We feel interested in this question as an institution, for students coming to us are not ready to receive for themselves, and prevent the giving to others who are ready, the instruction which we could and desire to furnish; and we are thus hindered from accomplishing the full measure of results which we feel we might otherwise attain.

It seems proper that schools established for the benefit of agriculture and the mechanic arts, of which this is one, should encourage the art of drawing, particularly industrial drawing. There was a time when industrial education would have been regarded not only as an innovation, but almost as a heresy, even if the meaning

of the term were understood. The importance of this education was greatly underrated; special training was provided, and large sums of money provided for young men who intended to enter the learned professions; but the young Wattses and Stevensons developed in a chilly atmosphere of neglect and indifference. It was only when the English public found the markets of the world, which they had sometimes seemed to regard as their peculiar heritage, occupied by France and other European nations, that they clearly perceived the necessity of promoting a system of thorough scientific education as the first groundwork for material national prosperity. The lesson of the World's Fair of 1851 was a bitter one to English prejudice and tradition in education. Commercial prudence overcame ancient prejudice, and English manufacturers regained their place in the world's markets when English money and care founded and fostered the South Kensington and the many other schools for industrial education.

In this country, the General Government, some of the State Governments, and several private citizens have, in recent years, aided in the establishment of many similar institutions. Such schools are evidences of the need felt by their founders, many of them practical business men and manufacturers, for a trained labor, and of their sense of the necessity of providing suitable opportunities of imparting the desired education. Business men are the first to see the business needs of a State, and to provide for them. In promoting industrial education, they simply take money from one pocket to secure an increased return into the other. Recently a representative of one of the leading industries of a large manufacturing city in this State was induced, by his sense of the needs and his appreciation of the advantage of industrial drawing in his business, to propose the offering of prizes to the pupils in the public schools of this city, for the best designs for oil-cloths, table-cloths, wall-paper, etc.

We may safely say that the mills of Massachusetts would never have achieved their present reputation but for the school-houses; that the system of training in industrial drawing, and of industrial education generally, so well developed and so efficiently conducted in that State, has made possible the improved machinery and increased skill, whose products are held in so high repute. The State law, which makes it possible for all cities or towns of five thousand inhabitants, and obligatory upon all of more than ten thousand, to "annually make provision for giving free instruction in industrial or mechanical drawing," etc., has given the wheels of those mills a new impetus.

In all institutions devoted to industrial education, industrial drawing is regarded as one of the principal supports or most essential factors in the system. And just here it may be well to meet an objection to the introduction of drawing into all schools, by indicating what we deem the proper character to be given to this drawing

Industrial drawing is not what may be called æsthetic drawing. Its object is not to make "pictures." In the latter, the artist aims to represent a combination of objects, real, imaginary, conventional or conventionalized, for the purpose of producing a pleasant effect upon the eye and mind of the beholder. Its purpose is artistic or "effect." In industrial drawing the draughtsman aims to represent primarily, forms and relations as they are in the object represented, existing or to be produced. Its purpose is utility or "service." When this principal object has been attained, the decorator may and does add such lines of figure or other design as shall increase the beauty of the object, while consonant with its purpose but never interfering with it.

Drawing is too often regarded as an accomplishment merely, without possessing any really practical value. The apathy manifested in many instances when it has been proposed to introduce this subject as one of the regular branches in the school curriculum, gives unfortunate indication of the mistaken notions too prevalent of its scope and purposes. And if allowed a place in the course, it is generally assigned a position such that teachers, pupils and parents understand that it is "of little account"; but the instruction in drawing, which we advocate, which we should be gratified to see introduced into every school in the State, and which we give in this "State College for the Benefit of Agriculture and the Mechanic Arts," so far as the facilities furnished us allow, which we feel is essential to the highest development of any manufacturing interest—industrial drawing—furnishes not only bread and butter in *any* community, but in one whose manufacturing interests are great it provides strong meat, out of which are formed the bone and the muscles of a strong and efficient body of industry. The duty of the State toward its children, its future citizens, is to make, or assist in making, them as efficient as possible factors in diminishing waste of its economic possibilities, in husbanding its resources, and in increasing its wealth.

Drawing has an educational value, which is universal in its character. It develops closeness of observation, accuracy of perception, vividness of imagination, quickness of eye, facility of hand, care and judgment in expression. It cultivates a knowledge of relations, of fittingness and adaptation

–all useful in the general duties of life, and which render their possessor either better producers or better fitted to appreciate the products of labor which was guided by this training.

There are few States in the Union in which the subject of Industrial Drawing is so important as in New Jersey. Her varied industries make constant demand upon the designer and draughtsman. The last report of the Bureau of Labor and Statistics of the State gives $82,871,863.12, as the value of the manufactured products in those industries where drawing is essential to accurate work and prevention of waste, and $20,528,017.30, as the amount of wages paid to laborers in those industries. To this should be added the values of buildings erected, bridges built, railroads, steam and other boats constructed, none of which are included in the report, and the sum assumes a magnitude which makes the neglect of anything tending to conserve and promote the efficiency of these interests seem culpable.

Industrial Drawing is one of the most important links, binding together and showing the relation between the school and the practical industries of the country; giving, more than most others, direct and appreciable results of the training of the former upon the products of the latter. It is scientific, artistic and educational; scientific to properly secure the accuracy of permanent and economic workmanship; artistic, to add the enhancing quality of beauty of form or decoration to the products of that workmanship; educational, in the training of the faculties which it gives; and it is always practical.

The Department of Graphics in this institution aims to assist in securing for and to the industries and people of New Jersey the benefits which are possible for them in this branch of education.

3. ASTRONOMY.

The Daniel S. Schanck Observatory is a two-story brick building, with revolving dome, constructed especially for astronomical work. It contains in the main part the equatorial telescope, mounted on a pier of solid masonry extending several feet below the surface of the ground, and detached from the floors, through which it rises, so as to be unaffected by the tremors of the building. The telescope is eight feet four inches in focal length, with an aperture of six and one-half inches, and was made by the late Henry Fitz of New York. It has a small telescope attached for a finder, a driving clock, a position micrometer, a number of

eye pieces (two of superior quality having been recently added), a prism and glasses for solar observations. The declination circle is ten inches in diameter, reading by verniers to one minute of arc, and the hour circle, seven and one-half inches in diameter, reads by verniers to six seconds of time.

On the west side of the main part is an extension for transit observations. The meridian circle used for this work was made by Stackpole & Brother of New York, and has an object-glass four inches in diameter and four feet ten inches in focal length, which circles seventeen inches in diameter, reading by two microscopes with micrometer screws to single seconds of arc. The diaphragm carries one horizontal and nine vertical wires. There is also a striding spirit-level and an apparatus for reversing the axis of the instrument. The bearings rest on two stone pillars supported by piers of masonry.

The Observatory has also a sidereal clock, by Wm. Bond & Son, the gift of John Clark, Esq., of New Brunswick, with an electrical break-circuit; a mean solar clock, the gift of the Piethessophian Society of Rutgers College, and a reflecting circle, the gift of the Philoclean Society of Rutgers College, and a chronograph loaned to the Observatory by the Superintendent of the United States Coast Survey.

The Observatory is in connection with the United States Naval Observatory and others, by the Western Union Telegraph Line, so that observations may be compared by exchange of time signals. The instruments are all in good working condition, and the student of practical astronomy has here every facility for learning the methods of astronomical observation. Practice is acquired in observing transits both by the "eye and ear" method, and by chronographic signals, and also in making differential measurements with the micrometer.

A familiarity with the refined methods of measurement which astronomical instruments afford, and the habit of thinking for one's self which the use of such instruments helps to form, are in themselves no small means of mental culture. Add to this the familiar acquaintance with the elements of spherical astronomy and the useful methods of computation which the practical study of this most perfect of the sciences imparts, and the advantage and satisfaction to the student are readily manifest.

The elements of astronomy are taught by the use of a text-book and by lectures four times a week during the last term of the Junior year. Those who elect a special course in astronomy receive further instruction three times a week through the Senior year, learning the use of the instruments and taking part in the observations. Post-graduate students

can take a still more extended course. Among the subjects included in the course are the following:

Theory and use of the instruments.
Determination of instrumental errors.
Determination of sidereal, apparent and mean solar time.
Transformation of different systems of co-ordinates.
Reduction of observations for refraction and parallax.
Determination of latitude and longitude.
Reduction of stars from apparent to mean place, and *vice versa*.
Theory of interpolation.
Combination of observations by the method of Least Squares.
Calculation and projection of eclipses.
Calculation of ephemerides.
Calculation of the orbits of comets and planets.

4. PHYSICS.

Instruction is given in Mechanics, Sound and Light, four times a week during the first two terms of the Junior year. "Deschanel's Natural Philosophy" is used as a text-book, but is largely supplemented with lectures, explanations and problems. The subjects are treated both experimentally and theoretically. The students are required to take notes of the lectures and experiments, and of the solution of exercises, and these notes are at intervals inspected by the instructor.

The Mechanics included in the first part of this course serves not only as a good preparation for the subsequent parts of General Physics, but also as an introduction to Analytical and Applied Mechanics in the Engineering Course.

The work of the lecture-room aims to make the principles clearly understood, both in their nature and their application, by the following methods:

1. By experimental illustrations.

2. By their use in the explanation of these illustrations, or of well-known phenomena.

3. By their application to the solution of numerous exercises of a practical character.

Quite an extensive supply of physical apparatus, to which additions are made as needed, permit a large variety of illustrative experiments. It is not the sole or chief aim in teaching this science to store the mind with facts, but rather to

develop the reasoning powers and accustom the student to trace the connection between cause and effect. After grasping a general principle established by observation and experiment, he is exercised in deducing from this general law the numerous and varied consequences which, under stated conditions, flow from it. Students who wish to pursue further a special subject by experimental investigation under the direction of the instructor, have opportunity given as far as present means allow.

When desired by a sufficient number of students intending to teach Physics in public or private schools, a brief course of lectures will be given in the spring term on the methods of teaching, with special reference to such easy experiments and illustrations as may be given with apparatus which can be constructed or obtained at a very small expense. During the first two terms of the Senior year, the subjects of Heat and Electricity occupy two hours per week. Deschanel's book is used as a basis, and all necessary amplifications are introduced into the lectures, both from more extensive works and the current literature of the day.

The application of the Science of Heat to the warming and ventilation of houses, to the steam-engine and to the weather, is made by such illustrations as will tend to fix principles, as well as facts, permanently in the memory. The subject of electricity is presented with equal fullness of detail in its relations to natural phenomena and modern industrial progress.

Throughout the whole course in Physics, care is taken to show the intimate connection of the various branches of science, and to give to the novelties of the day no more than a just share of attention. The concluding part of the course is devoted to such suggestions and directions as are judged to be calculated to stimulate to and guide in original work.

5. CHEMISTRY.

Inorganic, Organic, Applied, Analytical.

(a) *Inorganic Chemistry.*

Chemistry is taught with increased fullness every year. Upward of twenty hours per week are devoted to this science, and ample time thereby given to the student to digest and assimilate each subject, presented in successive portions. It is believed, as the result of careful inquiry, that no other institution devotes more time to instruction in Chemical Science.

Students in all the courses of the school have four terms

of lectures in the various branches of Chemistry, and are required to take full notes, in order to train them in habits of accurate observation and facility of expression. These notes are taken in pencil, and are afterward copied out in ink and handed in to the Professor for examination, criticism and correction.

During the first term, devoted to Inorganic Chemistry, the theory is presented, the construction of formulæ taught, and the chemical relations of air and water experimentally shown. The rudiments of the philosophy of gases are impressed upon the students by abundant illustrations. Especial care is taken, at this early stage of progress, to make all experiments demonstrative, so that pupils may learn to discriminate between mere hypothesis and theory based upon facts. The most approved forms of apparatus are used, when best suited to elucidate the subject, but in many cases familiar utensils are employed, for the sake of associating with them in the mind the principles learned, which will be likely to come more frequently to the recollection than would be the case if both principles and apparatus were strange.

The second term is chiely occupied in considering the non-metallic elements, both theoretically and practically.

The third term is devoted to the metals in their purely chemical relations, preparatory to an understanding of Technical Chemistry.

(b) *Organic Chemistry.*

Organic Chemistry is taught by lectures and recitations. Beginning with an explanation of the determination of the molecular weight of organic compounds, the student is led to examine the principles of substitution, valence and structure of organic compounds. Starting out from Methane, the various members of the Methane (mono-carbon) series are derived. When this series has been completed, the Ethane series is taken up and gone through with in the same manner. Then follow the Butane and Propane series, and so on.

The manner of teaching and treating the subject is substantially the same as introduced by Prof. Hofman of Berlin; as the various substances are considered, their relations to vegetable and animal life and to agriculture are pointed out. Attention is also given to their practical applications, as in food, beverages, medicines, coloring, dyeing, soap-making, illuminating, etc. The lectures are accompanied by full experimental illustrations.

(c) *Applied Chemistry.*

The applications of Chemistry to the arts and manufactures are taught by the lectures, and illustrated by experiments so far as it is possible. So far as is possible, the actual products are exhibited to the students, and the manufacturing processes reproduced in miniature. Attention is drawn to the scientific relations and connections between the various manufactures. The great losses by imperfect methods of manufacture and by waste-products are pointed out, and the student is taught to see the true economy of production. Illustrative of the lectures, visits are made to various manufacturing establishments, of which there are a number in and about New Brunswick, and an opportunity is given to see the manufacturing operations in actual working.

(d) *Analytical Chemistry.*

Three rooms in the Geological Hall are at present devoted to chemical analysis. These, with the annexed balance room and store-rooms,.and the general lecture-room, occupy the first floor of the building.

Twenty hours per week are devoted to this branch on chemistry. An extensive stock of apparatus is kept of hand in the supply-room, so thatthe student is able use the most modern appliances in his analyses.

In beginning the study of Blow-pipe Analysis, the student is first taught how to blow glass, and make much of his own apparatus. He is then made familiar with the properties of the various chemical elements by performing their characteristic tests, as laid down in the text-book. Having become acquainted with the properties of the elements, he proceeds to analyze substances, or, in other words, to apply, for the detection of the elements, the characteristic tests he has learned. In this manner he soon becomes expert at detecting even traces of metals, etc. The small size of the apparatus, and the ease with which analyses are performed by its aid, make it an instrument of great value to the professional man, whether he be a mining engineer desirous of examining an ore in a part of the country where only a candle is obtainable, or a physician wishing to detect, in a few minutes, the presence of arsenic, mercury, or various other metallic poisons in a suspected substance.

In all cases the student works with his note-book at his side, and must note down his work as he proceeds. The analyses are reported immediately after their completion, in printed forms, and filed for reference. The aim of these

reports is manifold. Students are compelled to write down a clear and concise account of their experiments; and to be able to keep an accurate written record of their work is alone an important thing. They learn to describe natural phenomena in explicit notes—a very useful, and for the scientific man, an absolutely indispensable acquirement. In reporting, they rigidly preserve the three great divisions of experimental science, *Experiment*, *Observation* and *Inference.* They thus become perfectly at home in practical logical deduction. Their minds are developed by their continual use of practical logical demonstration, in a way that only actual familiarity with experimental work can effect. The continual striving to express their ideas in a concise and logical form inculcates a thorough idea of system and business habits.

Determinative Mineralogy has been made a special branch of instruction. By the aid of the blow-pipe and a few chemicals, the student is soon able to determine the nature of any mineral or ore.

The examinations in Blow-pipe Analysis having been successfully passed, the study of Qualitative Analysis is entered upon. Here a far more complicated set of apparatus and chemicals is needed. While Blow-pipe Analysis can detect only a limited number of substances, Qualitative Analysis includes all the elements. The student begins in the same manner as with the blow-pipe. He performs the characteristic test, and learns the manipulations. He soon enters upon actual analysis. From the most simple substances, he proceeds gradually to more difficult ones, until his analyses include the most complicated and difficult mixtures. Accompanying the practical work in the laboratory, full courses of lectures and recitations are given, by which the student is given a clear idea of the theory of the subject. The course concludes with examinations in the theory and practice of analysis.

Quantitative Analysis now begins. While in his former studies the student has learned how to detect the constituents of a substance, he now learns how to determine their *amount.* Here he acquires the delicacy and accuracy of the quantitative method, in which the slightest speck of matter represents a certain weight, and becomes familiar with the handling of costly instruments of precision. The student analyzes, at first, compounds of known and fixed composition. As soon as he has acquired the necessary skill and manipulation, he analyzes substances of variable composition, as feldspars, limestones, clays, slags, cast-iron, steels, ores of many kinds, iron, zinc, nickel, copper, lead, tin, arsenic and antimony, German-silver, bronze, type-metal,

pig-lead, paints, waters, superphosphates, guanos, milks, sal-soda, acetate of lime, sugars, bone-black, coal, soap, petroleum, flour, wine, poisons, etc. Lectures are given on the general theory of Quantitative Analysis, which explain minutely the method in use. The students are required to hand in once a week a written method, with reference to the text-book, for the analysis of supposed mixtures. These papers are criticised and discussed by the Professor. In this way the student gains a really exact and practical knowledge of the whole subject, and is never at a loss for a method in the analysis of a substance with which he has not had previous analytical experience.

In addition to the above subjects, a course in microscopical investigation will soon be added. A room is also to be fitted up for a thorough course in practical assaying of ores, or fire analysis. In the Blow-pipe, Qualitative and Quantitative Laboratories, improvements and extensions are constantly being introduced, which, with the increasing stock of apparatus and chemicals, will soon make them unsurpassed in thoroughness.

In the practical study of Analysis the student is able to apply and carry out the theoretical principles of Chemistry which he has learned in his lectures on General Chemistry. The continual practice in detecting substances by their characteristic appearances under varying conditions, and the necessity in every case of rigid experimental proof, become habits applicable to all things in actual life, and give the student a drilling and foundation in practical logical deduction and induction that are of incalculable value to him.

The student concludes his course in the laboratory by undertaking an original experimental investigation on some point connected with theoretical or applied Chemistry. He now leaves the firm ground of known facts and methods, and enters on the limitless fields of investigation and discovery. It is here that his enthusiasm is fully aroused, and his determination and energy display themselves. He discovers new facts, handles new substances, invents methods, originates expedients and learns the value and power of discovery. Failures only incite him to effort. Perseverance and determination to succeed become habitual to him.

It is in this field that the most strenious efforts are being made toward development, for it is by this advanced teaching alone, that the student can be made to think and act for himself, place confidence in his own powers, and raise himself by *original* thought and work in the profession he adopts.

The Professors in charge allow a free reference to their

own books, and the College Library is open daily for consultation. The fundamental idea of the plan of instruction is to make the students independent, by teaching them not only what a routine analyst ought to know, but also the proper use of the books upon the subject. Inasmuch as many students in the regular course intend to pursue Medicine, Agriculture, etc., and hence will not be likely to make analyzing a business for themselves, they are taught also to know when and how to have analyses made, and shown how the habits of exactness and system acquired in a laboratory are important elements of mental training.

Special students in Chemistry are, of course, required to spend much more time at work, in order to acquire greater facility. Such students are required to hand in at the end of each term a thesis on some subject assigned to them for study. At the end of the summer they prepare a journal of travel or observation, which embodies the description of any interesting scientific objects encountered during the vacation.

We have good reason to believe that any one, on leaving the laboratory after a full course, is competent to devote himself with success to any line of business connected with Chemistry, without further need of instruction. Medical students invariably say that their course at College has proved invaluable to them. By degrees it is becoming more evident to the public that a rapid and thorough development of the industrial resources of our country demands not only a trained class of original workers, but a spread of scientific information among the masses, in order that opportunities for employing specialists to advantage may not pass unobserved.

Practical chemists must necessarily spend most of their time in the laboratory. The farmers and men engaged in industrial pursuits generally, ought to know what chemists can do, and ought to be able to judge pretty nearly when a chemist's aid is advantageous. The aim, then, is to teach analysis, both as a means of educational and mental discipline and as a profession, or means of earning a livelihood.

There are now ten students engaged in Chemical Analysis, of whom three are special students and one a post-graduate.

6. ENGLISH LANGUAGE AND LITERATURE.

In the recently organized department of English, the students are required to study the history of the English language, the history of English literature, and a selection of English prose and poetry; and to write essays in literary criticism which call for the careful study of the best authors. This is supplemented by a course of systematic private read-

ing prescribed for examination. It is impossible in the time allotted to this branch, in the short period of a college course, to conduct the student over the vast field of our literature. The course can only aim to create a love for literature, train the student in the critical study of it, and impart so much of the literature itself as will enrich his mind with the best thought and his speech with the most expressive diction of our mother tongue.

The value of such a course is now fairly recognized, although the course is wanting in very many institutions, especially of science, and of but recent introduction in those in which it has been admitted. Neither our own language nor literature can be safely left wholly to the student himself or to the incidental acquisition which is made in the use of our language in the other departments. A distinct and independent position in the course is necessary to the thorough and systematic study required to make it valuable. It is especially important in a scientific course, from which the ancient classics are excluded. It takes the place of Latin and Greek. Although it cannot give the linguistic training afforded by the ancient classics, the student can enter more fully and thoroughly into the literature itself, and receive the training which literature alone can impart. When we reflect that English is his own literature, and will form the staple of his reading and the occupation of his leisure, in after-life, the importance of laying the foundations in college becomes clearly apparent. No study will more ennoble and refine his taste, imagination and heart. It is the one great fine art for the culture of the American student, removed from the vast collections and training of the other fine arts enjoyed by the foreign student.

7. MILITARY.

In September, 1880, Lieutenant S. N. Holmes, Thirteenth United States Infantry, reported for duty in this department in compliance with orders from the Adjutant General of the Army. The object of the instruction in this department is to give that elementary knowledge which every good citizen should possess, that he may the better aid his country in time of need, and in so doing give such military training and exercise as will add to the health and physique of each student, while contributing something to the general discipline of the College. As no arms have yet been received from the United States Government, the drill has not gone beyond that of the soldier without arms. In the meantime, lectures have been given, illustrating campaigns under the old

order of battle, the handling of men on the march and in camp, and a description of the parts and mechanism of the arms with which our regular troops are now equipped. In another year it is intended to place these improved arms in the hands of the students, when it is hoped that without trenching upon the ordinary college instruction, this department may turn out citizen-soldiers whose zeal and accomplishments shall be worthy of a State whose National Guard has recently won so brilliant a reputation in the competitive test at Yorktown.

8. THE MUSEUM.

The Museum of the College occupies the second and third stories of Geological Hall, consisting of one large room, with galleries and store-rooms at the south end. The main room is ninety by forty, and twenty-five feet high, large windows on both sides, and at the north end give an abundance of light, and so distribute it that everything is exhibited to the best advantage. On each side, under galleries, there are seven double cases, so placed as to make an alcove at each window. These are sufficiently large to admit narrow, open cases in front of each window, whenever additional space for the exhibition of specimens is demanded. These side cases contain drawers below and shelves above. The former serve for the storage of duplicates, the latter hold those on exhibition. The cases on the east side are devoted to mineralogy and metallurgy. Of these, one is filled with a complete collection of minerals for the use of students of mineralogy. They furnish material for use in blow-pipe analysis, for the ordinary chemical examinations, and for the illustration of the general principles of mineralogy, as crystallization, etc. Here are small suites showing degrees of hardness, electrical characters, magnetic properties, cleavage, etc. Three of the side cases are filled with larger and better examples of the minerals, arranged according to the system of Dana. These can be studied, under special arrangements, by more advanced students. The collection is good and equal to the wants of elementary instruction, and for post-graduates to an advanced position. Three cases are filled with ores of the various metals, one containing iron ores, a second those of zinc (including handsome specimens from the celebrated mines of Sterling Hill and Franklin Furnace), and the third with native gold and silver, and ores of copper, lead, nickel, antimony and other metals. Among the copper compounds there is a very fine collection from the mines of Chili, South America, the gift of Miss Evans, of New Brunswick.

The west side cases hold a part of the paleontological and geological collections, grouped according to their age. One case contains specimens which illustrate the formation and structure of rocks. These occupy the shelves and are always to be seen by the student of geology. Below them is a suite of five hundred specimens from Dr. Krantz, of Bonn, also for students' use. They represent by typical examples all the geological ages and periods, and give a general notion of the succession of the formations of the earth. In the remaining cases, the characteristic rocks and fossils of the Silurian, Devonian, Carboniferous, Triassic, Cretaceous and Tertiary and recent ages are so arranged that the various changes in the condition of the earth and its animal and vegetable life are traced from the eozoon of the Archaic rocks to the frail shells that are to-day filling up our lakes and marshes with shell-marl.

On the main floor there are five cases of ores, minerals and rocks, and two cases containing the collections of recent birds and animals.

Two of the cases contain typical specimens of the rocks, ores, marls, clays, sands and other native minerals of New Jersey, which are used in manufactures and agriculture. This collection is largely a duplicate of that exhibited by the Geological Survey at the Centennial Exposition at Philadelphia. It presents to the view of the student the varied natural resources of the State.

Two cases are filled with the Beck cabinet of minerals. In these new cases this unique and valuable collection shows to advantage, and in an appropriate and peculiar manner testifies to the diligence of Dr. Beck as a collector and mineralogist. Aside from its intrinsic importance, it will serve to call up pleasant recollections of this distinguished scientist, so long connected with the College.

A pyramidal case in the centre of the room exhibits a showy lot of quartz crystals and associated minerals from Ellenville, Ulster county, New York. The larger part of them were in the original Lange collection, which was bequeathed to the College a few years ago.

At the south end of the room there is a series of red sandstone blocks, twenty feet long and six feet wide, on which are ninety-four foot-prints. They were taken from the quarry of John H. Vreeland, Whitehall, Morris county, New Jersey. These tracks are of the well-known genera of Brontozooum, Grallator and Tridentpes—extinct bird-like animals which lived in the Mesozoic age. The distinctness of the markings, their large size and their long stride attract the attention of visitors. They are valuable as types in comparing the red sandstones of New Jersey and the Con-

necticut Valley, and in the study of the forms of life which made them.

For illustrating iron-working, two collections are particularly noticeable. One of these is a set of T-irons from the Trenton Iron Company; the other a similar one of T-irons and of rails from the Union Iron Company, of Buffalo, New York. Many other metallurgical specimens, in iron, zinc, copper, lead, nickel, silver and gold, show how these metals are obtained from their ores, and form a valuable nucleus for a metallurgical cabinet.

The few specimens of recent birds and animals occupy two large cases. This very important department is in need of large additions.

The conchological collection has been classified and beautifully arranged by George W. Tryon, of Philadelphia, in a series of flat cases running around the sides of the gallery.

The collection is large and equal to the needs of the most advanced collegiate course. It is well filled with the most characteristic species and genera of living mollusks.

The most conspicuous object in the Museum is the skeleton of the whale which was caught in the Raritan river four years ago. The skeleton is suspended in the centre of the room, near the level of the gallery floor. It illustrates on a large scale, to the student of anatomy, the mammalian skeleton, and becomes a type in a series of such forms.

A human skeleton serves for the study of human anatomy.

The Indian antiquities and other ethnological material have been arranged in one of the cases of the main floor. The collection is small, but contains valuable relics, and shows the character of the remains of our aboriginal population.

A collection of the native woods of New Jersey has recently been placed in a new case in the south gallery. It numbers about one hundred pieces, and exhibits nearly all of the common woods found growing in our State. Some additional specimens are still much needed, to make it full and representative.

The glass cases of the Museum are inadequate to the proper display of materials in store, and additional floor cases are wanted to fill up the main room, besides smaller cases for the galleries, in which to place zoölogical and botanical specimens.

These statements indicate an increase in the attractive objects of the collection, as well as in the valuable specimens for aid in object-teaching; but the wants of the Museum are still large, since no collection is too full for the complete survey of any department of natural history, although quite adequate to the more limited requirements of the ordinary

college student: but for a scientific school and for specialists it cannot outgrow their needs.

The Museum is open every afternoon when the College is in session.

The Museum continues to be remembered by its friends and the generous patrons of the College, and the steady growth of the various collections is evidence of their interest in it. Among the additions of the year which are noteworthy are:

Collection of Woods native in the United States, from the United States Census Office, Department of Forestry, and sent by Prof. C. S. Sargent, Director of the Arnold Arboretum of Harvard University. This collection contains nearly 400 species, which have been determined at the Arnold Arboretum. They are valuable for reference in studying our New Jersey woods, and instructive to the general student of botany.

Minerals from Stassfürt Salt Mines, Germany, from Francis A. Wilber, B. S., of the Faculty. These minerals are fine specimens of the unique and characteristic Stassfürt species. They are well-exhibited in sealed glass jars.

Two stuffed specimens of Ornithorhyncus paradoxicus, or Duck-billed Platypus from Australia, the donation of Mrs. Oswald Miller; a rare gift.

Collection of native birds, through the liberality of friends in New Brunswick. Mr. Gerard Hardenbergh, of the city, has been engaged to prepare and set up a collection of birds, which are common in the vicinity of New Brunswick. A number have already been placed in the museum. They will represent our locality and form the beginning of an ornithological cabinet suitable for illustration in this branch of natural history.

The Museum is attracting a greater number of visitors each succeeding year. Through the enthusiastic efforts of students, of graduates and generous friends, its collections are growing and becoming not only more attractive to the ordinary visitor, but also affording valuable material for the proper and effective teaching of the several branches of natural history.

VII. THESES.

The following abstracts of a portion of the theses read before the State Board of Visitors by members of the last graduating class, are thought likely to be of interest, both on account of their subject-matter and as specimens of the work done by our students;

"RAILROADS, ENGLISH AND AMERICAN," BY F. W. MALCOLM, B. S. '81.

Course in Engineering.

Originally, English and American railroads were alike in many particulars; but so many and such important changes have been made, both in England and in America, that the two systems are now quite distinct. I will attempt in this article to review some of the principal points of difference; not, however, dealing with the construction of earth-works, bridges, signals and depots, nor with the financial management of the companies, but with the differences in permanent ways and rolling-stock which characterize the two systems.

* * * * The formation level which receives the ballast is, in England, made flat on the top; for cuttings, 43 feet, and embankments 33 feet in width In America, the formation level is slightly convex (as shown in the Figure); for cuttings, 34 feet, and embankments 28 feet in width. It will be noticed that for cuttings the average width of English exceeds that of the American by 9 feet, and for embankments by 5 feet. The greater width of the English formation level is due, in cuttings, to the large allowance for side ditches; and on embankments to provide against the possibility of the train rolling down the embankment should it leave the rails. * * * * Broken stone and slag best answer the purposes of a good ballast. English engineers distribute the ballast in two layers, called upper and lower ballast. The lower ballast is composed of stones varying in size from 3 to 30 cubic inches. In the upper ballast the stones do not exceed 3 cubic inches. In this country, the broken stone is of uniform size, about 2½ cubic inches, except between the tracks, where it is somewhat larger. * * * Ties or sleepers are of two kinds, longitudinal and transverse. Longitudinal sleepers are in use on several English roads, giving entire satisfaction. They are also used at some terminal stations in this country. * * * * Wrought iron sleepers will eventually supplant the wooden sleepers now in use. * * * * The double-headed rail is used very largely in England, but not in this country. The advantages claimed for it are, vertical strength, ease of manufacture, and two wearing surfaces instead of one. On the other hand this form of rail lacks lateral strength, besides requiring the use of chairs, which add to the cost of the road at the rate of £800 per mile. The complication of double and

single chairs at switches is sufficient to condemn the use of this form of rail.

The weight of rails in England varies from 60 to 85 lbs. per yd. (95 lbs. per yd. in Ireland); and in this country from 60 to 75 lbs. per yd. * * * * In England rails are rolled from 15 to 21 ft. in length, the latter length being the more common. Rails 60 ft. in length have been rolled in this country, but rails of such a length are very apt to be imperfect. * * * The English method of fastening the rails or chairs to the ties is vastly superior to our own. * * * * Spikes are easily applied and are comparatively cheap, which account for their use in this country. They possess no merits save those above mentioned. On entering the tie they tear down the fibre of the wood, forming cavities in which water may lodge, causing decay and consequent loosening. * * * * Few of the fish-joints now in use accomplish what they should, that is, support all of the rail vertically. * * * *

The standard gauge is the same in both countries—4 ft. 8½ in. There are many wide variations to be met with in both countries. * * * * The protection offered to the public by our railroads, at crossings and depots, as compared with that on English roads, is greatly to our disadvantage. There the laws insist upon all tracks being properly fenced in and guarded, and upon all crossings of railroads, even of carriage-ways, being constructed upon different grades. There the laws are strictly enforced; here they are only brought to mind after some serious accident. * * * * The use of these forms of couplers (Miller and Janney) has led to a certain uniformity in the height of sills of passenger cars, and it is to be hoped that a standard height for freight-car sills will soon be established. * * * * English roads cost, according to statistics given by Mr. Flint, $179,000 per mile, and American roads only $35,000, per mile.

"RAILROAD SWITCHES," BY ROBT. C. PLUME, B. S. '80.

Course in Engineering.

Though many important improvements have been going on abroad as well as among ourselves in the manufacture of switches since railroads were first constructed, yet the systems do not differ materially from one another at the present day, and especially is this similarity true between those of the United States and Great Britain. In fact, many of the latest inventions are common to both of these countries. Hence, from the brevity of time allowed, it is my intention to

speak particularly of the railroad switches of America and their improvements, rather than of those of foreign countries.

The word "switch" comes from the German "*seveig*," and means literally a branch. A switch consists simply of two movable rails, generally a part of the main track, and connected by so called tie-rods. These rails can be moved by a lever so as to connect either with the main track or siding.

The oldest and most simple form of switch in use is that known as the "Stub Switch." It consists merely of the two movable rails clamped by tie-rods, so as to work together when thrown back and forth by means of the lever. The "Three-throw Switch" (Fig. 1) is merely a single stub switch with an additional set of turn-out rails. The only material difference is the enlargement of the chairs to allow the introduction of these rails. This switch, although comparatively safe on our leading railroads, with their modern appliances of signals, etc., has serious imperfections and is open to many objections, the principal one being due to the large open joints, which cause, by continual jarring, great wear and tear on both rolling-stock and rails. Again, the same defect is the cause of great annoyance to the road-masters. The interlocking of the rails by expansion in summer, and the growing so far apart by contraction in winter, make their frequent removal necessary. Several switches somewhat similar to the stub switch have been introduced at various times. The "Dooley Switch," designed to lessen the jar and shock produced by the wheels passing over two open joints at once, is essentially the same, save in one particular, that of having one joint set a few feet back of the line of the other. Consequently, the wheels pass over but one joint at a time. The number of jars, however, being doubled, it would tend toward very little improvement in the end.

Many devices have been invented to prevent trains from running off the track, when by accident the switch is set wrong. These are known as "Safety Switches." Some of the best of these are the "Split Switches," where the switch rails are pointed and somewhat automatic. A train on either track will force over the switch, should it be set wrong, so as to continue on the main track. These switches have the advantage of leaving an unbroken track at the points, consequently no jar occurs to a train in passing over them. Great care, however, must be taken in putting the rails into position. Both the shoulders and split rails must have the same elevation upon an iron plate, otherwise derailment will take place. One of the best and the most general in use of the split switches is the "Lorenz Safety Switch" (Fig. 2).

This switch has been adopted as a standard by several of the largest and best-equipped roads in the country, and is considered the safest of the split-rail system. The chief merit of the Lorenz switch is that the switch, whether set for the main track or siding, always presents one rail continuous or unbroken. Consequently no jarring or noise is experienced when running over it. Probably, the most prominent and widely-used of all is the "Wharton Switch" (see Fig. 3). The distinguishing feature of this switch is that the main track is entirely unbroken. Consequently, for a road which sacrifices everything else for its main track and fast running, this switch is preferable to all others. The Pennsylvania Railroad, which is undoubtedly the most finely-equipped road in the United States, if not in the world, has adopted the Wharton for its main line, and the Lorenz for its yards.

The operation of the Wharton switch is very simple. Suppose it to be set for a siding and the train moving from left to right in the drawing. The grooved rail guides the flange of one wheel out on the siding while the opposite wheel passes over the elevating rail, which being somewhat higher than the main track rail causes the flange to clear the latter. The wheel is then carried down by a gradual descent to the proper level of the other rail. When the switch is set for main track, the movable guard-rail is some distance from the main rails, but when the switch is set for a siding this rail is thrown over against the main-track rail by the same action of the lever which sets the switch. Now, in the drawing, suppose a train to be moving from right to left and the switch be still adjusted for the siding. The flange of the first wheel coming in contact will force the guard-rail away from the main track, and consequently, by means of the draw-rod (6), will force the whole system back to the main track, leaving it clear and unobstructed. Hence, we see that the worst that can happen on a double track road is, that the train might pass on a turnout track instead of keeping on the main one; merely losing the few minutes required to return to its proper position.

Still another safety switch known as the "Tyler Switch" is used to some extent on several roads. It consists simply of two extra rails with castings at their ends, so arranged that if the switch should be left wrong, these rails will receive the wheels and guide them safely back to the main track.

A switch, differing considerably from those already described, has been introduced lately on some of the Western roads and is recommended particularly for yard service. This switch is known as "Elliot Lap Switch," and is somewhat a remedy for both the open joint and pointed switches.

Until within the last twenty years the rails were made either of cast or wrought iron. Since then the steel rail made by the Bessemer process has become the standard rail for all of the best switches. The superiority of steel over iron for the manufacture of rails cannot be disputed. Steel rails are not only more durable, but they are much stronger for the same amount of material. Many of the large switch manufacturers make their own steel. This is done because of the great care that is necessary in selecting iron for the steel. Only that containing very little phosphorus can be used. This substance, unless sparingly used, has the effect of making the rails very brittle. This, together with punching holes for fish-bolts, caused at first the breaking of rails to be a common occurrence. But the process of manufacture has of late years been brought to such a high state of perfection that the breakage of steel rails is now very rare. Of the other parts of the switch, the rail-chairs and blocks are made of cast-iron, while the rest are usually of wrought iron.

"ASPHALT PAVEMENTS," BY T. H. GRANT, B. S., '81.

Course in Engineering.

The need of a pavement which shall offer the least resistance to traction and afford a secure foothold for horses has long been felt, and has produced a brood of projects which, for the most part, have proved to be total failures. Although asphalt pavements are of this class, they have given so much satisfaction in many instances that they merit special attention.

The matrix or binding material is asphalt, an oxygenated hydro-carbon, produced by the decomposition, beneath the surface of the earth, of animal and vegetable substances. It is a bitumen, and is closely related to mineral tars, petroleum and naphtha. Asphalt is widely distributed and is found both in a liquid state and also incorporated with carbonate of lime, forming bituminous limestone. There are two methods of preparing asphalt for road-coverings.

The first or French method is substantially as follows: Bituminous limestone, containing from nine (9) to twelve (12) per cent. of asphalt, is broken into small pieces and heated to about 250° Fahr., at which temperature it falls into a partially coherent powder. It is immediately transferred to the street to be paved, spread evenly to the proper depth while hot, upon a suitable base (preferably hydraulic cement concrete), and compacted with heated rammers and heavy rollers. Pavements thus constructed are smooth, durable and elastic, and have been much admired and exten-

sively laid in Paris. In 1880, there were 370,000 square yards of asphalt in that city.

The second method of preparing the paving material, or the one usually followed in this country, differs considerably from the first. Instead of using the bituminous limestone, which in itself contains all the constituents needed, each component is obtained from a different source, and so combined with the others as to produce a substance similar to that obtained by heating the asphalt rock. The matrix is Trinidad or Cuban asphaltum, refined by heating to 300° Fahr., to which, in order to reduce it to the proper consistency, is added some heavy oil, as the residuum of refined petroleum, which will withstand a fire test of 250° Fahr. About sixteen (16) per cent. of oil, by weight, is added to Trinidad asphalt, and twenty-three (23) per cent. to Cuban, the difference being due to the fact that the latter contains a greater percentage of asphaltene. The product obtained by the union of these two hydro-carbons at a temperature of 300° Fahr. is the asphaltic cement.

To obtain a solid material in the form of powder, to replace the carbonate of lime of the natural asphalt rock, sand and pulverized limestone are used. The sand, which should be fine, clean and sharp, is heated to about 300° Fahr., to drive off the moisture. It is then mixed with the cold limestone dust, and directly afterward is incorporated thoroughly with the asphaltic cement, the proportion by weight being as follows:

Asphaltic cement	16 per cent.
Pulverized carbonate of lime	17 "
Sand	67 "

The resulting mixture is a dark-colored partially coherent powder, and is immediately carted to the street. It is laid upon a hydraulic base in two coats. The cushion coat and the wearing surface. The first should be one-half-inch in thickness when compacted, its objects being, 1st, to provide an even bed for the wearing surface, and 2d, to act as a cushion or spring. The second layer, or wearing surface, which should be two (2) inches in thickness when compressed, is next laid. The asphalt mixture, heated to not less than 250° Fahr., is spread evenly to the depth of three and one-fourth inches, and partially compacted with rollers of four or five hundred pounds, after which a dusting of hydraulic cement is applied, to give the pavement a lighter and more agreeable color. It is then further consolidated by a steam roller weighing about ten (10) tons.

The above method of preparing and laying asphalt is preferable to that pursued in Paris, where the bituminous limestone is used, since it may differ in the proportion of asphalt to the carbonate of lime. If the rock is rich in asphalt, the pavement will be soft and sticky in hot weather, but if it is poor, the surface will crack in cold weather. Whereas, by our method the degree of malleability is absolutely under control by varying the proportions of the constituents. Washington has one million square yards of asphalt pavement, or six hundred thousand square yards more than any other city in the world. It is mostly in fine condition and possesses advantages over other pavements.

The merits of asphalt laid in a monolithic sheet are briefly as follows:

1st. Smoothness and evenness of surface and consequent ease of draught. It does not polish and therefore affords a secure foothold for horses.

2d. Cleanliness. It is composed of such materials that it can of itself produce no dust, and having no joints to collect or retain dust or liquids, all foreign matters can be easily swept off.

3d. Durability. Asphalt being a neutral substance, is not affected by surface liquids; neither can it be affected by frost, as it is impervious to water. The wear is very slight, not exceeding, when properly laid, one-sixteenth of an inch annually. There is abundant evidence showing that asphalt has sustained, without injury, loads of from eighteen to twenty-four tons, and that there are pavements now in good condition which have been laid from nine to fifteen years.

4th. Economy. As respects first cost, asphalt is the cheapest of all good pavements. In 1880, 154,000 square yards were laid in Washington, at prices ranging from $1.47 to $2.04¾ per square yard. In regard to maintenance, the same holds, since the asphalt is laid in two coats and the wearing surface may be quickly removed and relaid, when worn out. The price usually paid for entire resurfacing with two and a half inches asphalt is from eighty-five to ninety cents per square yard.

Asphalt makes a desirable pavement, at a reasonable cost. It will withstand a wide range of climate and possesses most of the essential merits of the best pavements, besides other advantages of great value, peculiar to itself. It is smooth, though not slippery, elastic, does not disintegrate into dust or mud, while its strength and tenacity insure for it great durability.

"THE HUDSON RIVER TUNNEL," BY O. A. JOHNSON, B. S., '81.

Course in Engineering.

The purpose of this great work, which has excited the interest of engineers and speculators for years, is to establish direct railroad communication between the business centre of New York city and the West and South by way of the Erie, Pennsylvania Central, New Jersey Central, Delaware, Lackawanna and Western and other railroads, by the construction of a railroad through a tunnel of such capacity as to be able to convey all passengers and freight, amounting to three hundred trains daily, without change of cars and without delay from all parts of Jersey City and Hoboken into the city of New York.

The Route.—After careful scrutiny, extensive borings and soundings and a due regard to the wants of the public and the connecting railroads, the location has been made in Jersey City on a line extending easterly from Jersey avenue on Fifteenth street to Hudson street, about 3,900 feet; thence curving slightly northward to the New York bulk-head line at or near the foot of Leroy street, about 5,500 feet; thence curving slightly southward about 3,000 feet, to a point near Broadway to be selected. The commencement of this work was made by sinking a perpendicular shaft or well thirty feet in diameter by sixty feet deep, at a distance of one hundred feet from the water, at the foot of Fifteenth street, Jersey City. This shaft is built in a solid manner and lined with a four-foot brick wall. The bottom of the shaft is the level of the roadway of the tunnel. On Saturday, Feb. 12th, '81, I visited the tunnel, and in company with the civil engineer and the mechanical engineer passed through the airlock, in order to get some practical knowledge of the work inside. The method of driving the tunnel is as follows: A cylindrical iron ring is first formed by bolting together plates three feet long by two and a half feet wide at the top of the ring, and six feet long and two and a half feet wide at the sides and bottom of the ring; these plates are placed in position as soon as the silt has been sufficiently excavated. The miners make their first excavations at the top of the tunnel, and the plates are so arranged that each ring toward the rear extends a little lower down than the ring in front of it, until the last completed ring is reached.

The masons immediately follow the miners, and line the inside of the completed iron rings with brick masonry laid in hydraulic cement. The brick work is also laid in a series

of steps, but these ascend toward the completed tunnel instead of descending, as in the case of the iron rings. A pilot tunnel is built in sections or rings four feet long each, made up of ten segmental plates bolted together by inside angle-irons, and the sections joined in the same way, making a tube six feet in diameter, which is carried into the silt some twenty feet ahead of the other work, and which is a support for radial braces to keep the plates in position until the brick-work is completed. The manner in which this tunnel is being built differs from anything heretofore attempted in this line, in that the principle is adopted of using compressed air to keep out the water, and partially to uphold the earth. The air pressure now used in the tunnel is from seventeen to twenty pounds per square inch, thereby exerting a uniform pressure of more than two thousand pounds upon each square foot of exposed surface of the tunnel, which supplies the place of bracing; a pressure which is under complete control, and which can at a moment's notice be increased or diminished to any required extent. But it not only does away with a costly and tedious system of timbering, always heretofore considered as an essential adjunct to tunneling, but it also acts as a motor, driving the engines that supply the workmen with water required to mix the cement, and also to puddle the waste silt preparatory to driving the latter out of the tunnel. When the silt has been properly prepared, a stop-cock on a six-inch pipe, which extends from the bottom of the heading to the outside, is opened, and the compressed air in the tunnel blows this silt through the pipe to the surface; but only about one-half of the waste silt is blown out, the remaining half being thrown back into the completed part of the tunnel, there to remain till the approaches are built, when it can be more rapidly and economically removed by trains of cars. The tunnel is lighted by electric lights. Communication is had with the outside by telephone. The mouth of the tunnel consists of an air-lock, made of boiler iron. It is six by fifteen feet inside, and appears much like an ordinary boiler. Twenty men can easily pass through it at a time. A narrow railway track runs through it, on which a car loaded with materials for the work is run into the tunnel, though the brick is taken through a chute.

There are three shifts of workmen, each shift composed of forty men, and working eight hours daily, so that the work proceeds day and night throughout the twenty-four hours. Four feet of tunnel are completed each day. When the tunnel is completed about four hundred trains can pass through it daily, most of the freight going through in the night. Probably compressed air will be used as a motor.

"CREAM OF TARTAR," BY JOHN BRUERE, B. S., '81.

Course in Chemistry.

Cream of tartar, or more properly, hydrogen potassium tartrate, exists naturally in the juice of the grape, being held in solution by the saccharine matters present. It is, however, insoluble in alcohol. Hence, as the sugar of the grape juice is gradually converted into alcohol by fermentation, it is deposited. In the crude form it is known as argol, and is dark red and impure. When pure, it is called cream of tartar, and is then pulverulent, having a gritty feel and a pleasant acid taste.

A ton of grapes yields, according to the nature of the fruit, from one to two pounds of argol, which in good samples affords an average of eighty-three per cent of cream of tartar. Argol is an article of export from the wine-producing countries. The best comes from Italy and Southern France. It is used as a source of tartaric acid and the various tartrates used in medicine and the arts. The cream of tartar of commerce is rarely perfectly pure, generally containing a small percentage of calcium tartrate. In the arts, argol is used as a source of soluble tartrates, rochelle salts, tartar emetic, tartarized iron, and salts of tartar. In the pure state it is used in medicine as a cathartic, refrigerant, diuretic and aperient.

Cream of tartar is largely used in the household for raising bread and cake. When mixed with bicarbonate of soda and mingled with the dough, a chemical reaction takes place, forming sodium potassium tartrate, rochelle salts and carbonic acid, the latter, which is slowly evolved, inflates the dough and renders it porous and light.

Cream of tartar being a white powder rather difficultly soluble in water, can easily be adulterated with any article of a like nature and color. For this purpose it has been stated that sawdust, clay, gypsum, flour, chalk, alum and potassium sulphate have been used. The article has been examined at various times, and almost always found to be more or less adulterated.

The samples represented in the following examinations were bought of various apothecaries and grocers in the city of New Brunswick. The total number examined was thirty, and of them fifteen were found to be adulterated. It is worthy of note that none of the samples obtained from apothecaries were found to be bad.

No.	Insoluble Residue: Sand and non-volatile matter.	Insoluble Residue: Starch and volatile matter.	Sulphate of lime.	SO_3 combined with bases other than lime.	Total per cent. of adulteration
3	3.60	37.96	32.59	....	74.15
5	2.50	36.71	23.76	3.13	66.10
7	1.65	29.90	27.07	3.92	62.54
10	0.05	0.30	53.24	....	53.59
11	6.38	0.63	69.50	....	76.51
12	....	....	76.50	....	76.06
13	1.61	11.22	44.95	2.41	60.19
14	0.50	....	75.26	....	75.76
15	1.68	33.72	26.73	3.47	65.57
16	....	....	48.04	....	48.04
18	....	....	53.85	7.40	61.25
22	....	....	49.38	....	49.38
29	2.88	....	51.44	2.74	57.06
30	0.25	6.47	69.50	....	76.22

The theses of Mr. J. F. McWilliam on "Nostrums," and of Mr. C. S. Rusling on "Baking Powders," will be published in next year's report.

VIII. THE AGRICULTURAL DEPARTMENT AND STATE FUND.

The operations of the Agricultural Department during the past year are set forth in the accompanying report of the Professor in charge.

The amount of money received from the State Treasurer for the fiscal year ending October 31st, 1881, is six thousand nine hundred and sixty dollars ($6,960), which has been expended, as the law requires, exclusively for the salaries of Professors in the Scientific School.

Respectfully submitted,

WM. H. CAMPBELL,

President of the Board of Trustees.

AGRICULTURAL COLLEGE FARM.

REPORT ON THE AGRICULTURAL COLLEGE FARM, FOR THE YEAR 1880-81.

BY GEORGE H. COOK.

THE WEATHER AND THE SEASONS.

Our notes of the seasons close with the month of November. The year, as that of 1880, has been marked by extremes of temperature and slight rainfall. The distribution of both heat and rains has been irregular. The winter of 1880-81 was long and cold. The mean monthly temperatures for the winter months were several degrees below the average means thus far recorded here. The ground was covered very uniformly with snow throughout January and the greater part of February. And a large part of the precipitated moisture of the winter was in the form of snow. The winter grain and meadows were thus protected during the severe cold. The water from the melting of the snows and the rains of February and March filled the springs to an unusual height, so that with the coming of warm weather all the conditions for rapid growth were present. But the weather was cold through March and April, and up to the ninth of May. The pasture was slow in starting and was later than usual. April and May were marked by light rains; and the combined fall of these months was less than half the usual amount. The distribution of rain through May, in six storms, sufficed to keep all vegetation in a thriving condition. May was marked by a wide range of temperature, and the latter part of the month was prematurely warm. June was a delightful month, favored with a

low range of temperature, from 50° to 88°, and with light rains at intervals of two to ten days, which amounted to 5.94 inches. There was a luxuriant growth of the grain, but the hay crop was shortened by the want of rain in April. The long and severe drought began on the twenty-ninth of June and continued until the thirtieth of October. During this period of four months, the following slight rainfalls, with their corresponding dates, are noteworthy, viz.:

August 2	0.98 inches.
" 7	0.60 "
Sept. 10	0.26 "
" 12	0.24 "
Total	2.08 inches.

Or less than one-half the usual monthly amount in the summer and 12 per cent. of the mean quantity for this period. When it is considered that the evaporation in the summer months is more than three inches from land surface for each month, it becomes possible to conceive some idea of the extent to which the drying must have gone and the amount of moisture pumped up by the capillary forces of the soil and the sub-soils. The effect of such a drought was disastrous to growing crops, but its effects extend beyond a single season, and are felt in the accumulation of salts in the soil and sub-soil drawn up from below. These saline substances must be of benefit to succeeding crops, and experience has shown that they go far to compensate for the immediate damages from drought.

The mean temperature of July was below the average for that month during our record of fourteen years. The maximum also ran below the usual mark. On the other hand, August was slightly warmer than its mean temperature and the extreme heat exceeded that of any previous August covered by our record. And there was at the end of the month and running into September a week whose mean temperature reached 75.4°. September reached the climax of excessive heat and drought combined. The mean daily temperature was 72.44°, which was 7.44° above its normal mean. The maximum of 103° on the 7th is higher than any previously recorded extreme at this place. The heat was sustained throughout the month, and the minimum of 59° is unparalleled. But the striking character of the month is shown by the mean temperature of 76.62° for the last eight days of the month. Or in other words, the ten days from September 23 to October 2 were quite as warm as our usual July weather. Under the influence of so extreme

heat and an almost entire absence of rain, vegetation suffered greatly. The corn was so dried up that it was cut early. The ears were short and the crop was about one-quarter the usual yield in this vicinity. Potatoes did better, especially the earlier planting. All late root crops were about a failure. Pastures were burned up, and farmers were compelled to fodder their stock. The drought affected the springs seriously, and many became dry. The fine spring at the College Farm was lower than it has been at any other time in many years. Small streams also ran dry, and inconveniences in getting water for the animals, as well as for household purposes, were sorely felt. On account of the dry weather, the first sowing of winter grain quite generally failed to come up, making a second sowing necessary. The hot period ended about the fourth of October, and the cold wave of the fifth and sixth brought with it a minimum temperature below 30°, which manifested itself in the first frost of the season. It did not, however, do us much harm, excepting to very tender vegetables. The remainder of the month was warm and pleasant, although dry; and there was no frost again until November fifth. The drought was ended by the rains of November thirtieth and December first, which amounted to .86 inch. The month of November also has been remarkable for its fair weather, rain having fallen on four days only, and the total quantity amounting to 2.05 inches. The deficiency for the summer and autumn months, up to date of closing this report, is about seventy-five per cent.

TEMPERATURE AT NEW BRUNSWICK.

MONTHS.	MEAN.		MAXIMUM.		MINIMUM.	
	1863–1870 and 1876–1881.	1881.	1863–1870 and 1876–1881,	1881.	1863–1870 and 1876–1881.	1881.
1881.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.	Degrees.
January	28.3	22.7	67	45	−12	−7
February	30.0	26.7	67	52	−10	−1
March	36.7	34.5	77	58	4	22
April	48.5	43.4	81	75	21	21
May	58.9	62.7	98	90	37	42
June	68.0	64.7	93	88	46	50
July	74.9	71.7	101	90	56	60
August	72.1	72.1	99	99	48	60
September	65.5	72.4	103	103	42	59
October	54.1	58.6	89	89	29	35
November	39.2	44.1	74	69	11	20
1880.						
December	31.1	26.0	65	47	−8	−8
Av. year	50.6	50.0				

DEPTH OF RAINFALL, IN INCHES, AT NEW BRUNSWICK.

MONTHS.	Average from 1854 to 1881.	1881.
January	3.29	7.35
February	3.00	4.37
March	3.35	4.51
April	3.68	.43
May	3.83	2.53
June	4.09	5.94
July	4.58	0.00
August	4.96	1.58
September	3.19	.50
October	3.35	.86
November	3.35	2.05
		1880.
December	3.69	2.46
Yearly rainfall	44.36	32.58

ACREAGE OF CROPS ON THE COLLEGE FARM IN 1881.

	ACRES.
Fultz wheat	9.31
Australian black-bearded wheat	1.05
Rye	1.27
Oats	9.42
Indian corn	14.18
Sweet corn	.63
Sorghum	1.90
Fodder corn	6.30
Potatoes	1.03
Garden vegetables	.14
Clover and timothy	41.00
Pasture—cows	5.03
" pigs	.73
	91.99

Turnips, second crop, 1.78.
Fodder corn, second crop, 1.00.

Of the $97\frac{4}{10}$ acres in the farm, there have been $91\frac{99}{100}$ acres in crops. The remainder is occupied by buildings, yards, roads and fish-pond of about one acre. There is no wild or waste ground on the farm.

Wheat—The Fultz wheat was a very fair crop for the season. It is not yet all threshed.

The Australian wheat was so very fine in the grain that

we expected a valuable addition to the varieties of that grain by our farmers. An acre of our best ground was sown with it. It made a most extraordinary growth in the fall of 1880, and gave promise of being much heavier than the Fultz wheat grown on equally good ground. But it would not stand the severity of our winter; most of it was killed by the frost, and that which was left was very much damaged and made only a feeble and sickly growth. It is not a kind of wheat to be depended on in our climate, and we shall grow no more of it.

Rye—The crop of this grain was remarkably fine and heavy. We have never failed to grow good crops of rye on the farm. The amount of grain and straw produced has not yet been measured and weighed, but it is so large as to become a fair subject of inquiry whether it is not a more certain and profitable crop than wheat.

Oats—The oat crop was much better than common. Throughout all this vicinity the crop of oats was heavy, and although ours was grown on good ground, its superiority was undoubtedly due to the unusually favorable season.

Indian Corn—We had a very promising field of corn, planted where we have before grown seventy to eighty bushels of shelled corn to the acre. The dry weather injured it very much, and we did not get more than five hundred bushels of ears on fourteen acres of very good ground.

Sweet Corn—This crop suffered from the drought quite as much as the field corn did, and we have nothing to show for the planting.

Sorghum—This crop was grown for experiment; sixteen plots were tried with different fertilizers, and fourteen or fifteen different varieties of sorghum were tested. Sorghum was affected considerably by the drought, and the crop much shortened, but it was evidently less injured by dry weather than most other farm crops. It is troublesome and expensive to cultivate, in the earlier stages of its growth, but when fairly rooted it grows very fast. It has yielded fairly in sugar and fodder, and in seed. The details of the experiments with it will be found in this report, further on.

Fodder Corn—Our plans were to raise a large supply of this excellent forage plant this season. We had plots planted and fertilized with superphosphate, with muriate of potash, with sulphate of potash, and with barn-yard manure. But much of the seed corn failed to germinate, and the dry weather so damaged that which grew, that we only had a very unsatisfactory crop. We hoped to have made a fair test of the comparative merits of thick or thin planting. That thinly planted stood the drought better. A part of the fodder corn was ensilaged, and has not yet been fed out; another equal portion was dried in the usual way, and we propose to make a comparative trial of the feeding value of equal quantities of the green corn fodder, one being ensilaged, and the other cured in small shocks in the field. The experiments on these were about beginning at the date of this report.

Potatoes—We get but a light crop of these, though the field is a very good one. Our soil and sub-soil are not adapted to the best growth of potatoes.

Clover and Timothy—Our crop of hay from these is a fair one—not as large as we have had in some former seasons—but it was very good.

Soja Beans—We made another trial of these beans this year, planting them very thick in two rows 128 feet long, upon very good ground. They grew well all the season, and ripened evenly, not being much affected by the extreme dry weather. The crop of beans from the rows was twenty-two pounds. They can be easily planted and properly tended in rows two feet apart. This appears to be a good way of growing them. Last year we tried to grow them by *sowing* the seed, but they were soon overrun and choked by weeds, and the crop was worthless. This year success is very encouraging. An acre of ground, at the rate these rows produced, would yield thirty-one bushels.

The seed was obtained, part in Munich and part in Vienna, in 1878, and it has now been planted three times without showing any signs of deterioration from our climate or soil. It has some most valuable properties as a farm crop. To quote from the paper sent out by the Bavarian Experiment Station: "We need a fodder for young cattle, for milk cows and for bullocks, whose seeds contain, in proper amount, albumen and fat, with a pleasant taste. In cereals and their brans, and also in leguminous seeds, we have fodder con-

taining albumen, but not fat enough. The addition of oil-cake is not entirely satisfactory, because the proportion of fat in it varies, and its cost is too great.

"Prof. Haberland, of Vienna, an untiring botanical experimenter, introduced to us a plant whose pleasant-tasting seeds are rich in albumen and fat, in very digestible forms. This plant is the hairy soja bean (*Soja hispida, Mönch*). Prof. Haberland found samples of the seed at the Vienna Exposition among the agricultural products of China, Japan, Mongolia, Trans-Caucasia and India. He says this plant has been cultivated from early ages. It grows wild in the Malay Archipelago, Java and the East Indies, and is cultivated extensively in China and Japan. Its seeds, boiled or roasted, have a pleasant taste, and form an almost daily part of the food in India, China and Japan.

"The soja is an annual leguminous plant, with a stalk from twelve to eighteen inches high, and with medium three-parted oval-pointed leaves, hairy on both sides. The small, reddish flowers are axillary. The pod is one to one and a half inches long, and three-eighths of an inch broad; a stiff-haired laterally-closed pod, containing two or three oval yellow or brown seeds, the size of the field pea. Its large leaves shade the ground and improve its physical properties.

"In 1876, twenty experiments were made in various parts of Bohemia, Moravia, Southern Austria, Styria, Hungary and Upper Silesia. From the well-ripened seeds from these crops one hundred and thirty-five trials were made the next year, under various climatic influences. Prof. Haberland has written us that only twelve of the experiments failed, and most of the results were unusually good. It has harvested from thirty-three to fifty-five bushels of seed and two and one-third tons of very nutritious straw to the acre.

"Prof. Schwackerhofer, of Vienna, has analyzed the original and the harvested seed, and the soja straw, with the following results:

	Original Seed.	New Seed,		Soja Straw.
		1st Crop.	2d Crop.	
Albuminoids	30.56	34.37	34.97	9.43
Fat	15.81	18.25	18.39	2.51
Carbhydrates	33.80	28.32	....	36.03
Fibre	4.67	4.30	....	29.45
Ash	5.12	4.76	....	10.14
Water	7.96	8.62	7.89	12.44

The following is the composition of the beans grown on the College Farm this year, which is the third year's growth with us:

Albuminoids	35.39
Fat	19.01
Carbhydrates	26.17
Fibre	4.96
Ash	4.83
Water	9.64
	100.00

The superior value of these beans will be better appreciated after an examination of the composition of some of our best-known feeding substances, and a comparison of the results. We put timothy hay and clover first in the list, as these are well-known, and their three constituents, albuminoids, fats and carbhydrates, are in such proportion as to keep animals in full flesh and healthy condition.

And as there are no data for determining the digestible qualities of the soja beans, the composition, and that of the other of the various substances, may be used without any important error arising from it.

SUBSTANCE.	Ash.	Albuminoids.	Fat.	Carbhydrates	Comparative Value per 100 Pounds.
Timothy hay	4.5	9.7	2.2	45.8	$ 93
Clover hay	5.3	12.3	3.0	38.2	1 00
Oat straw	4.0	4.0	2.0	36.2	59
Cured corn-fodder	4.2	4.4	1.3	37.9	59
Indian corn	1.5	10.7	4.9	66.5	1 29
Oats	2.7	12.0	6.0	55.7	1 26
Wheat bran	5.1	15.0	3.2	52.2	1 26
Malt dust	6.71	25.9	1.1	45.5	1 49
Cotton-seed cake, decorticated	7.6	38.8	13.7	19.5	2 45
Brewers' grains	1.2	4.9	1.6	11.1	36
Horse beans	3.1	25.5	1.6	45.9	1 59
Soja beans	4.8	34.7	18.3	28.3	2 55

In this table the soja bean is shown to have the highest value of any of the substances named, and by mixing it with oat straw or cured corn-fodder, it will make a rich and healthful fodder for cattle, and one which can be afforded in greater quantity and at less expense than first quality timothy or clover hay. It would form, too, a proper crop to be

in the rotation between corn and wheat, instead of oats or potatoes, as now practiced. It is not subject to the same difficulties in curing as our common field bean, as the beans do not easily shell out, and coarser stalks enable it to be cured like Indian corn.

We hope in another year to be able to make some feeding experiments with the soja bean.

Turnips—260 bushels of cow-horn turnips were grown as a second crop on one and three-quarter acres of sod, after the crop of hay had been taken off. The seed was sown broadcast at the rate of six or eight ounces per acre, and much of it was killed by the drought; but the crop was unexpectedly good, and is a valuable addition to our stock of cattle food for the early winter.

STOCK.

The stock kept upon the farm consists of a pair of mules and three horses for the farm work, and one horse for delivering milk to the customers in town and at the railroad station.

Forty-four cows are kept for producing milk, which is sold, a part to customers in New Brunswick, and part to a milk dealer in Jersey City. A few Ayrshire cows are kept, and an Ayrshire bull. A few heifer calves are raised, but the main part of the cows are of the common stock, raised by farmers in the vicinity, and purchased by us when in the fresh flow of milk.

A few pigs, mostly of the Jersey Red breed, are kept.

The leading business of the farm is keeping cows for the production of milk. The number has been increased from year to year, and may still be much enlarged, as we are able to invest more capital in the business. The limit must be found when the animals kept can consume all the hay, straw, corn-stalks, and coarse fodder grown on the farm. The large amount of manure produced is making the land more productive every year, and the yield of fodder greater, and it is probable that the number of cows to be kept can be properly enlarged to double its present amount. The cattle are not turned out to pasture in the spring or summer, but fed with green fodder in their stables, Some very satisfactory trials have been made in preserving green corn-fodder in a silo, and feeding it out in the winter. And we propose to try it on a larger scale next year, if all things are favorable.

The purchase of brewers' grains in summer, when they are very low-priced, and preserving them in cellars or pits in the ground, has been tried. The grains can be preserved and we are feeding some of them in the rations we make for the cattle, but they undergo some changes, and we are now comparing them with fresh grains, and have not yet come to any conclusion as to whether it is profitable to put them down in pits or not.

During the year, beginning December 1, 1880, and ending November 30, 1881, there have been sold 29,813 quarts of milk in New Brunswick, and 71,819 quarts in Jersey City.

IMPLEMENTS.

There have been two implements tried at the College Farm this season, which present strong claims to the attention of progressive farmers.

1. The Lion Cutter and Crusher, made at Mechanicsburg, Pennsylvania, by Hauck & Comstock, and sold by B. Gill & Son, Trenton. This implement is made in two sizes, No. 1, requiring from four to six horses to drive it, and No. 2, which is well driven by two horses. Our trials have been made with a No. 2 cutter, upon corn-stalks and dry fodder-corn. It cuts the stalks into about half-inch pieces, and then crushes or grinds them so that all the hard parts are split up into shreds. It cuts and grinds without difficulty, a half ton of the dry stalks in an hour. The cut and ground stalks are eaten greedily by the cattle, and there are none of the butts of stalks wasted as they are in the ordinary way of foddering them out. The machine also cuts and grinds straw or hay equally well with corn-stalks. In the present scarcity of fodder, after our severe drought, such a machine helps to economize stock-feeding stuff to a great extent, and as it enables farmers to feed up the whole of corn-stalks or dried corn-fodder as completely as it can be fed in ensilage, it raises the question whether it may not be as economical a way of preparing fodder-corn for winter use as it is to preserve the green stalks in silos. We have fodder-corn from the same field, preserved in both ways, and the comparative cost and value of them is now the subject of investigation by the New Jersey Agricultural Experiment Station. And this implement has furnished the means essential to carrying out the investigation.

2. Sackett's combined plow and pulverizer is an implement with two plows and a short skeleton cylinder. The first and forward plow skims the surface and deposits weeds and trash in the bottom of the furrow; the second and

larger plow follows, turns up a furrow to the required depth, and throws it into the rolling cylinder; the cylinder thoroughly crumbles and pulverizes the furrow slice and sifts the fine earth out upon that turned in by the forward plow. The soil worked by it was left as mellow as garden earth.

The implement is heavy and should have three horses to draw it. It was tried at the College Farm in August, when the ground was very dry and baked so hard that good work could not be done with common plows. It was hoped that a second trial could be made on the farm when the ground should be in good order for plowing, so that proper trials of the draft of this implement, in comparison with that of common plows, could be made, and measurements and observations taken on the amount and quality of work done; but no such opportunity has been offered. The machine is advertised by the Sackett Plow and Pulverizer Company, 198 Broadway, New York.

DONATIONS.

Messrs. Lister Brothers, of Newark, have donated to the College Farm one ton of their best superphosphate of lime.

The Hon. W. B. Miller, of Cape May City, has donated to the farm a liberal supply of early amber sorghum seed.

The United States Commissioner of Agriculture has sent to the farm for trial sixteen varieties of sorghum seed, also several varieties of wheat and oats.

EXPERIMENTS.

The experiments on the growth of Indian corn with different chemical fertilizers and with barn-yard manure, have been continued this year. The plots on which the experiments are made are part of the year's corn-field, and the soil is of the same grade of fertility with the rest of the field. It is not so generally instructive a series of experiments as could be made by beginning them on very poor and exhausted soil, and then continuing them from year to year on the same plots; but for the special purposes of our own farm, experiments on the soil as it is are best for guiding our yearly practice. This year the plots are on soil which has not been long in cultivation, which was originally wet and heavy, and which has been drained but a few years. It was stubborn and not very mellow, and was very much affected by the drought.

In former years the fertilizers have been applied to the

soil immediately around the corn-hills, but this year they were sown uniformly over the plowed ground and then worked in a little, before planting the corn.

The following is the result of the season's experiments:

TABLE I.

No. of Plot.	FERTILIZERS. KIND.	Amount Per Acre. Pounds.		YIELD PER ACRE. Shelled Corn. Pounds.	Shelled Corn. Bushels.	Stalks. Pounds.
1	Nothing			560	7	650
2	Nitrate of Soda	150		620	8	900
3	Superphosphate	350		370	5	450
4	Muriate of Potash	150		1940	24	900
5	Nitrate of Soda Superphosphate	150 350	500	650	8	750
6	Nothing			580	7	870
7	Nitrate of Soda Muriate of Potash	150 150	300	2020	25	1900
8	Superphosphate Muriate of Potash	350 150	500	1950	24	1700
9	Nitrate of Soda Superphosphate Muriate of Potash	150 350 150	650	1990	25	1620
10	Plaster	400		1480	18	1350
11	Fine Barnyard Manure	20 2-horse loads		950	12	1000

The experiments on corn for the season of 1881 are worthless. The extraordinary drought stopped the growth of the crop, and except for the importance of recording all our results, failures as well as successes, they might as well have been passed without note. It is interesting to notice that the plots are in the field which in 1875 yielded, with a complete manure, 100 bushels of shelled corn per acre.

TABLE II.

SUMMARY OF RESULTS OF EXPERIMENTS WITH SINGLE FERTILIZERS.

YEARS.	SULPHATE OF AMMONIA.			SUPERPHOSPHATE OF LIME.			MURIATE OF POTASH.			BARN-YARD MANURE,			NO MANURE	
	Pounds per Acre.	Bushels of Shelled Corn.	Pounds of Stalks.	Pounds per Acre.	Bushels of Shelled Corn.	Pounds of Stalks.	Pounds per Acre.	Bushels of Shelled Corn.	Pounds of Stalks.	Pounds per Acre.	Bushels of Shelled Corn.	Pounds of Stalks.	Bushels of Shelled Corn.	Pounds of Stalks.
1872	250	85	4638	500	73	6061	250	79	7104	------	----	----	69	6000
1873	----	----	----	----	----	----	250	59	4646	------	----	----	64	3945
1874	----	----	---	----	----	----	100	57	3787	------	----	----	48	3312
1875	400	86	5500	----	----	----	100	100	6150	32,000	93	6400	85	5500
1876	300	21	3250	500	24	3050	150	24	2950	------	----	----	26	2950
1877	300	70.6	4000	500	48.7	4000	150	50.2	4250	32,000	58.6	3650	55	4100
1878	300	22.4	1150	500	51.5	2500	150	59	4200	32,000	56	4350	40.3	2010
1879	300	30.5	2400	500	65	3850	150	63.6	4020	32,000	76	3900	54.6	3210
1880	300	52	1550	500	54	1400	150	58	4620	32,000	63	2600	57	1900
1881	*150	8	900	350	5	450	150	24	900	------	----	----	7	760
Av'gs	----	47	2924	----	46	3044	----	57.4	4263	------	69.3	4180	50.7	3369

* In 1881, Nitrate of Soda was used instead of Sulphate of Ammonia.

TABLE III.

SUMMARY OF RESULTS OF EXPERIMENTS WITH COMPLETE FERTILIZERS.

YEARS.	POUNDS PER ACRE.			YIELD.		NO MANURE. YIELD.	
	Sulphate of Ammonia.	Superphosphate of Lime.	Muriate of Potash.	Bushels of Shelled Corn.	Pounds of Stalks.	Bushels of Shelled Corn.	Pounds of Stalks.
1875	400	300	100	100	6700	85	5500
	200	500	100	104	7200		
1876	200	300	150	27	3150	26	2950
	100	500	150	35	3600		
1877	200	300	150	66.7	4700	55	4100
	100	500	150	66.9	4300		
1878	200	300	150	61.2	4150	40.3	2010
	100	500	150	60.1	3650		
1879	200	300	150	58.7	4100	54.6	3210
	100	500	150	60.7	3850		
1880	200	300	150	55	2850	57	1900
	100	500	150	57	2700		
1881	*150	350	150	25	1620	7	760
Averages	------	------	------	60	4044	46.4	2919

* In 1881, Nitrate of Soda was used instead of Sulphate of Ammonia.

The following conclusions may be drawn from the facts given in the above tables, viz.:

1. Neither sulphate of ammonia nor superphosphate of lime, used alone, has increased the crop of corn or of stalks. This is from the average for seven years.

2. Muriate of potash, applied alone, has increased the corn 13.2 per cent. and the stalks 26.5 per cent. This is from the average for ten years.

3. Barn-yard manure has increased the corn 36.7 and the stalks 24 per cent. This is from the average for five years.

4. The complete chemical manure has increased the corn 26.5 per cent. and the stalks 38.5 per cent. This is from the average for seven years.

5. By comparing the weight of corn with that of stalks in each case, that of

	CORN.		STALKS
Sulphate of ammonia is as	1.00	to	.77
Superphosphate of lime is as	1.00	"	.82
Muriate of potash is as	1.00	"	.93
Barn-yard manure is as	1.00	"	.75
Complete chemical manure is as	1.00	"	.84
No manure is as	1.00	"	.83

6. From these comparisons the inference must be drawn that barn-yard manure and muriate of potash are the best manures for corn on the College Farm soil.

NOTE—The corn and stalks were weighed when taken from the field, immediately after husking, which was about November 10th.

Sulphate of ammonia is worth from four to five cents a pound; superphosphate of lime about two cents; muriate of potash two and a half to three cents; complete chemical manure about two and a half cents, and barn-yard manure $1.50 a two-horse load.

SORGHUM.

The following tabular statements give the results of experiments on the cultivation of early amber sorghum with different fertilizers, and the yield of cane, sugar and seed from each; also the result of trials on the growth of several varieties of sorghum. The deficiencies in the last table are owing to the cane not being ripe when it was killed by the frost, as the sugar is not formed in the cane in full amount till the seeds are hard and ripe.

The sorghum was grown on a clayey and heavy soil which has been underdrained, and is capable of yielding good crops of corn, oats, wheat and grass, though it is rather hard for hoed crops The extreme drought retarded the growth of the canes, and finally diminished the crop very much. The planting was done on the 23d of May, and the crop was gathered on the 27th of September, The plants are very small and inconspicuous in the first part of their growth, so much so that persons accustomed to growing Indian corn have in some cases been discouraged and abandoned their fields, but later in the season the growth is very rapid. The seeds are planted either in hills, so as to cultivate both ways, or in drills with hills about two feet apart. Each method has its advocates. The heaviest expense in cultivating sorghum is in keeping it clear of weeds in the earlier part of its growth, and this may be greatly diminished by the ingenuity and skill of the workmen.

TABLE I.

	No Manure.	350 lbs. Superphosphate.	150 lbs. Nitrate of Soda.	150 lbs. Muriate of Potash.	350 lbs. Superphosphate. 150 lbs. Nitrate of Soda.	No Manure.	350 lbs. Superphosphate. 150 lbs. Muriate of Potash.	150 lbs. Nitrate of Soda. 150 lbs. Muriate of Potash.	350 lbs. Superphosphate. 150 lbs. Muriate of Potash. 150 lbs. Nitrate of Soda.	400 lbs. Sulphate of Lime.	20 Two-horse Loads Yard Manure.	200 lbs. Sulphate of Potash.	350 lbs. Superphosphate. 200 lbs. Sulphate of Potash.	200 lbs. Sulphate of Potash. 150 lbs. Nitrate of Soda.	200 lbs. Sulphate of Potash. 150 lbs. Nitrate of Soda. 350 lbs. Superphosphate.	200 lbs. Sulphate of Potash. 150 lbs. Nitrate of Soda. 700 lbs. Superphosphate.
Pounds of sorghum per acre	11515	13365	14820	16000	14440	11170	11640	12390	12590	12680	12375	11605	11650	12505	13260	14030
Pounds of stripped and topped cane per acre	8406	9890	11263	12160	10850	8378	8846	9293	9946	9510	9405	8820	8854	9504	9812	10943
Per cent. of juice extr'd from str'd & top'd cane	69.6	67.0	66.4	68.0	66.8	64.2	65.1	64.3	67.3	64.8	64.4	68.2	69.0	68.3	68.9	67.8
Pounds of juice extracted per acre	5851	6626	7479	8269	7234	5379	5759	5975	6694	6162	6057	6015	6109	6491	6760	7419
Per cent. of sugar in juice	9.70	9.43	9.00	9.27	9.68	9.94	10.51	11.65	11.43	9.84	9.57	11.61	9.73	9.73	9.44	12.01
Pounds of extractable sugar per acre	568	625	673	767	700	535	605	696	765	606	580	698	594	632	638	891
Pounds of clean seed per acre	1020	1351	1298	1246	1344	1132	1038	1067	1305	1136	1160	1216	1226	1139	1349	1278
Pounds of sugar extracted per ton of cane	135	126	120	126	129	128	137	150	154	128	123	158	134	133	130	163

The value of the sorghum crop is in the sugar, the seed, and the leaves and crushed canes.

Farmers have been in the way of raising sorghum for a number of years past, and of extracting the juice in rude mills, and then concentrating the juice by evaporation into a syrup. By their process the sugar was mostly changed to glucose and could not be made to crystallize. But it has been found that by pursuing the methods practiced in the best sugar-houses, a good yield of sugar can be obtained from the sorghum juice. A large sugar-house with complete equipment for the manufacture has been erected by Messrs. J. Hilgert's Sons, at Rio Grande, Cape May County, and sugar has been made there this year from the cane grown on 600 to 800 acres of land. The amount of cane grown was much smaller than expected, on account of the dry weather, but the manufacture was a success, and a large quantity of sugar was made, and that of a quality fully equal to the best grade of unrefined sugar from Louisiana or Cuba.

The seed is equal to Indian corn in its feeding value, and from two and a half to three bushels of seed are produced from each ton of cane.

No good experiments have yet been made to ascertain the feeding value of the crushed and pressed cane. It contains a considerable percentage of sugar, and should have some value for cattle food.

TABLE II.

NAMES AND TESTS OF SEVERAL VARIETIES OF SORGHUM.

	Wolf Tail.	Link's Hybrid.	Liberian.	Early Amber.	Neeazana.	Goose Neck.	Sorghum.	Early Orange.	Oomeesana.	Early Orange.	Regular Sorghum.	Gray Top.	African.	Honduras.	Chinese.	Early Golden.
Per cent. of juice						60.3	61.4		58.8				57.5			60.0
Per cent. of sugar in juice						8.58	7.28		6.50				7.60			14.06
Pounds of sugar extracted per ton of cane						103.47	89.40		76.44				87.40			168.72

Some of the varieties given in the above table were very promising in appearance, having much more the appearance of common Indian corn, than the Early Amber cane has, and they would doubtless produce a much heavier growth of cane and seed, but they are mostly too long in maturing. The only one that gives promise of being valuable here is that named Early Golden.

It should be remarked that the ground on which these varieties were grown was enriched by a liberal dressing of Mapes' sorghum manure.

The extreme drought of the season has probably diminished the crop materially, and we shall await the result of another year's experiments, with weather of the usual character, before drawing any conclusions as to average quantities and values of the product per acre.

It should also be remarked that Plots 2, 3 and 4 of Table I may possibly give a little too high products, from the effects of a pile of manure which was deposited at one end of these plots several years ago, though the pile was all removed at the time.

A much fuller discussion of these experiments will be given in the bulletin of the New Jersey Agricultural Experiment Station, by Dr. A. T. Neale, who has had them in charge.

RUTGERS

SCIENTIFIC SCHOOL

COURSES OF STUDY.

COURSES OF STUDY.

Four distinct courses of study are included in the schedule which follows:

I. A Course in Civil Engineering and Mechanics.

II. A Course in Chemistry and Agriculture.

III. A Special Course in Chemistry.

IV. A Special Course in Agriculture.

During the first year the studies of the two full courses are the same, and are designed to furnish a suitable introduction to the pursuit of the higher branches in either.

During the last three years, the subjects of Higher Mathematics, Mechanics and Engineering, in the Engineering Course, are replaced by Analytical Chemistry, practice in the Laboratory, and Agriculture in the other. The remaining subjects are pursued by the students of both courses together.

The course of study for the first year in this Department is arranged so as to be complete in itself. It is especially designed to meet the wants of those who cannot take the entire four years' course, but who desire to fit themselves as Land Surveyors. Students leaving at this period of the course receive from the Faculty a certificate of their attainments.

Students in this Department have daily practice in Draughting, with exercises and problems in Geometrical Constructions, in Descriptive Geometry, Topographical, Mechanical and Architectural Drawing, and in Graphical Statics. Students who acquire sufficient skill sometimes obtain positions as draughtsmen in various offices in the city during their course.

Special students are received, and allowed to take any part of the above course, provided their previous education is sufficient; and particular provision is made for them, especially in the Laboratory, in Mathematics, Surveying and Draughting.

The Special Courses in Chemistry and Agriculture occupy two years. The Laboratory is open from 9 A. M. until 5 P. M.

Students are instructed in Blow-pipe Analysis; Determinative Mineralogy; Analysis of Ores, Minerals, Coals, Waters, Technolog-

ical Products, etc.; Assaying; Analysis of Soils, Fertilizers, Agricultural Products and Foods; Volumetric Analysis of Gases; Detection of Poisons; Analysis of Urine and Animal Products and Microscopical examinations. The course of study depends to some extent upon the student's future pursuit in life.

MILITARY TACTICS.—In accordance with the requirements of the law, provision is made in this Department for the study of Military Tactics.

Special provision is also made for students who desire, after completing the regular course of study, to take post-graduate studies.

In connection with the instruction in Agriculture in this Department, the Trustees maintain an extensive model farm, designed to illustrate the principles of agriculture, and also to test by experiment the value of different systems. It is under the charge of the Professor of Agriculture, and *every Wednesday* during term time will be devoted to giving, upon the farm, explanations of the experiments and their results to the students in agriculture, as well as to any farmers who may desire to avail themselves of this privilege.

COURSES OF STUDY.

FRESHMAN YEAR.

Exercises during the year in Composition and Declamation. Bible Class Sabbath Morning.

FIRST TERM.

1. French. 2. Mathematics—Algebra, from Series, and Solid Geometry. 3. Natural History—Dalton's Physiology; Lectures. 4. Rhetoric—D. J. Hill; Lectures. 5. Draughting—Practical Geometry, Plane. 6. English Literature—Hale's Fruges.

SECOND TERM.

1. French. 2. Mathematics—Trigonometry, Plane and Spherical. 3. Natural History—Zoölogy; Lectures. 4. Elocution—Lectures. 5. English Literature—Lounsbery's History of the English Language; Trench on Words; Lectures. 6. Draughting—Coloring, Topographical Signs, &c.

THIRD TERM.

1. French. 2. Mathematics—Surveying, Murray's Manual; Field Practice and Mapping. 3. Natural History—Gray's Botany; Lectures. 4. English Literature—Brooke's History of English Literature; Lectures. 5. Draughting—Mapping, with Sections, &c.

SOPHOMORE YEAR.

Exercises during the year in Composition and Declamation. Bible Class Sabbath Morning.

COURSE IN CIVIL ENGINEERING AND MECHANICS.

FIRST TERM.

1. Railroad Curves—Henck's Field Book; Field Exercises and Plotting. 2. Descriptive Geometry—Church. 3. Chemistry—Lectures. 4. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 5. History—Freeman's Outlines. 6. Draughting—Practical Geometry, Solid. 7. Essays in Literary Criticism.

SECOND TERM.

1. Analytic Geometry—Bowser; Descriptive Geometry—Church; Construction of Problems. 2. Chemistry—Lectures. 3. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 4. History — Freeman's Outlines. 5. Draughting—Intersection of Surfaces, &c. 6. Essays in Literary Criticism.

THIRD TERM.

1. Analytic Geometry—Bowser. 2. Shades, Shadows and Perspective—Church; Construction of Problems. 3. Chemistry—Lectures. 4. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 5. History—Creasy's Constitutional History of England. 6. Draughting—Linear Perspective, &c. 7. Essays in Literary Criticism.

COURSE IN CHEMISTRY AND AGRICULTURE.

FIRST TERM.

1. Blow-pipe Analysis—Nason; Qualitative Analysis—Douglass & Prescott; Lectures; Laboratory practice. 2. Descriptive Geometry—Church. 3. Chemistry—Lectures, Barker. 4. Mental Philosophy— Porter's Elements of Intellectual Philosophy. 5. History—Freeman's Outlines. 6. Draughting—Practical Geometry, Solid.

SECOND TERM.

1. Qualitative Analysis— Douglass & Prescott; Lectures; Laboratory practice. 2. Descriptive Geometry — Church ; Construction of Problems. 3. Chemistry—Lectures, Barker. 4. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 5. History — Freeman's Outlines. 6. Draughting—Intersection of Surfaces, &c.

THIRD TERM.

1. Qualitative Analysis—Douglass & Prescott; Lectures; Laboratory practice. 2. Shades, Shadows and Perspective — Church; Construction of Problems. 3. Chemistry—Lectures, Barker. 4. Mental Philosophy—Porter's Elements of Intellectual Philosophy. 5. History—Creasy's Constitutional History of England. 6. Draughting — Linear Perspective, &c.

JUNIOR YEAR.

Exercises during the year in Composition and Original Declamation. Bible Class Sabbath Morning.

COURSE IN CIVIL ENGINEERING AND MECHANICS.

FIRST TERM.

1. German. 2. Differential Calculus—Bowser. 3. Natural Philosophy—Deschanel. 4. Political Economy—Bowen and Perry. 5. Draughting—Lettering, &c.

SECOND TERM.

1. German. 2. Differential Calculus, completed; Integral Calculus—Bowser. 3. Natural Philosophy—Deschanel. 4. Constitutional History of the United States — Text-book (Andrews) and Lectures. 5. Draughting—Shading, &c.

THIRD TERM.

1. German. 2. Integral Calculus, completed. 3. Astronomy. 4. History of Civilization—Guizot. 5. Draughting — Constructions.

COURSE IN CHEMISTRY AND AGRICULTURE.

FIRST TERM.

1. German. 2. Quantitative Analysis—Fresenius, Cairns; Lectures; Laboratory practice; 3. Agriculture — Lectures at the farm. 4. Natural Philosophy—Deschanel. 5. Political Economy —Bowen and Perry. 6. Draughting—Lettering, &c.

SECOND TERM.

1. German. 2. Quantitative Analysis — Fresenius, Cairns ; Lectures ; Laboratory practice. 3. Agriculture — Lectures. 4. Natural Philosophy—Deschanel. 5. Constitutional History of the United States—Text-book (Andrews) and Lectures. 7. Draughting—Shading, &c.

THIRD TERM.

1. German. 2. Quantitative Analysis — Fresenius, Cairns ; Lectures ; Laboratory practice. 3. Agriculture—Vegetable Physiology. 4. History of Civilization—Guizot. 5. Draughting—Constructions. 6. Mineralogy.

SENIOR YEAR.

Exercises during the year in Composition and Original Declamation. Bible Class Sabbath Morning.

COURSE IN CIVIL ENGINEERING AND MECHANICS.

FIRST TERM.

1. Mechanics—Tate or Wood. 2. Engineering—Mahan. 3. Organic Chemistry. 4. Moral Philosophy—Calderwood's Hand-book. 5. Draughting—Machinery and Architecture. 6. Chemical Physics.

SECOND TERM.

1. Engineering — Mahan. 2. Mechanics—Tate or Wood; Bridge Building, Wood; Indeterminate Analysis. 3. Organic Chemistry. 4. Moral Philosophy—Butler's Analogy. 5. Draughting—Engineering. 6. Chemical Physics.

THIRD TERM.

1. Engineering—Bridge Building and Railway Practice; Geodesy. 2. Geology—Lectures. 3. Moral Philosophy — Butler's Analogy. 4. Draughting; Thesis.

COURSE IN CHEMISTRY AND AGRICULTURE.

FIRST TERM.

1. Applied Chemistry. 2. Principles of Agriculture—Lectures. 3. Quantitative Analysis — Fresenius, Cairns, Lectures, Laboratory practice. 4. Moral Philosophy—Calderwood's Hand-book. 5. Draughting. 6. Organic Chemistry Lectures. 7. Chemical Physics.

SECOND TERM.

1. Agriculture — Its Methods and Products. 2. Organic Chemistry—Lectures. 3. Quantitative Analysis — Fresenius, Cairns; Lectures, Laboratory practice. 4. Moral Philosophy — Butler's Analogy. 5. Draughting. 6. Chemical Physics.

THIRD TERM.

1. Agriculture—Animal Physiology; Care and Management of Domestic Animals. 2. Geology—Lectures. 3. Moral Philosophy — Butler's Analogy. 4. Draughting. 5. Chemical Investigations. 6. Thesis.

Special Course in Chemistry.

FIRST YEAR.

FIRST TERM.

1. Inorganic Chemistry. 2. Blow-pipe Analysis. 3. Qualitative Analysis. 4. French. 5. Thesis.

SECOND TERM.

1. Inorganic Chemistry. 2. Qualitative Analysis. 3. Chemical Physics. 4. French. 5. Thesis.

THIRD TERM.

1. Inorganic Chemistry. 2. Quantitative Analysis. 3. Stoichiometry. 4. French. 5. Thesis. Journal of Travel or Observation.

SECOND YEAR.

FIRST TERM.

1. Organic Chemistry. 2. Applied Chemistry. 3. Chemical Physics. 4. Quantitative Analysis. 5. German. 6. Thesis.

SECOND TERM.

1. Organic Chemistry. 2. Applied Chemistry. 3. Chemical Physics. 4. Quantitative Analysis. 5. German. 6. Thesis.

THIRD TERM.

1. Applied Chemistry. 2. Chemical Physics. 3. Geology. 4. Assaying. 5. German. 6. Mineralogy. 7. Thesis.

Special Course in Agriculture.

FIRST YEAR.

FIRST TERM.

1. Algebra. 2. Geometrical Problems. 3. Inorganic Chemistry. 4. Physiology and Zoölogy.

SECOND TERM.

1. Geometry. 2. Coloring and Topographical Drawing. 3. Analytical Chemistry. 4. Mineralogy. 5. Book-keeping.

THIRD TERM.

1. Trigonometry. 2. Mapping. 3. Analytical Chemistry. 4. Botany. 5. Farm Accounts.

SECOND YEAR.

FIRST TERM.

1. Surveying. 2. Projections. 3. Natural Philosophy. 4. Study of Domestic Animals. 5. Systematic Agriculture.

SECOND TERM.

1. Navigation and Nautical Astronomy. 2. Architectural Drawing. 3. Physics. 4. Geology. 5. How Crops Grow.

THIRD TERM.

1. Leveling and Road Making. 2. Machine Drawing. 3. Meteorology. 4. Botany. 5. How Crops Feed.

Composition and Declamation throughout the whole course.

The hours of lectures or recitations are four each day, besides work in the Chemical Laboratory.

Students who pass their regular examination in the above subjects. will, at the close of their course, receive certificates of their attainments. And at the end of two or more years further, if they shall have pursued practical agriculture on a farm, and shall then pass satisfactory examinations in prescribed subjects on Agricultural Principles and Practice before a Board of Examiners of the Scientific School, they shall receive Diplomas in Agriculture.